EMPLOYMENT
FOR THE
MICROSCOPE.
In TWO PARTS.

I. An Examination of *Salts* and *Saline Substances*, their amazing *Configurations* and *Cryſtals*, as formed under the Eye of the *Obſerver*:

WITH

Plain Directions how to prepare ſuch Subſtances, and preſerve them in conſtant Readineſs for Inſpection; whereby the *Curious* may always be furniſhed with numberleſs Objects hitherto little known.

ALSO

Occaſional Conſiderations on *Gems*, *Poiſons*, the *Vegetation of Metals*, the *Reſuſcitation of Plants*, the *Formation of Amber*, *Corals*, and many other Subjects.

II. An Account of various ANIMALCULES never before deſcribed, and of many other *Microſcopical* DISCOVERIES:

With OBSERVATIONS and REMARKS.

LIKEWISE

A Deſcription of the MICROSCOPE uſed in theſe Experiments, and of a new *Micrometer* ſerving to ſhew the Size of magnified Objects.

Together with

Inſtructions for printing off any *Medal* or *Coin*.

Illuſtrated with Seventeen COPPER PLATES.

By *HENRY BAKER*, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries* of *London*.

Rerum Natura nuſquam magis quàm in Minimis tota eſt.
PLIN. Hiſt. Nat. Lib. XI. Cap. 2.

The SECOND EDITION.

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TO THE

RIGHT HONOURABLE

The Earl of Cardigan.

My LORD,

HIS Grace the late Duke of MONTAGU, (whoſe Name muſt be ever dear to all that knew him) was pleaſed to honour, with his particular Notice, the Experiments and Obſervations deſcribed in the following Sheets, and frequently expreſſed his Deſire of having them made public: and as your Lordſhip ſeemed no leſs to admire theſe wonderful Operations of Nature, I take the Liberty to requeſt your Acceptance of a Work, whoſe Novelty and Variety will, I hope, yield you ſome Entertainment, at the ſame time it affords me the deſirable Opportunity of profeſſing my moſt humble Reſpect.

The firſt Part of this Treatiſe diſcovers in the Particles of Matter compoſing Salts and ſaline Subſtances, Properties whoſe amazing Effects would ſurpaſs all human Belief or Conception, were we not convinced of their Truth by the ſtrongeſt ocular Demonſtration. That beautiful Order in which they arrange themſelves and come together under the Eye, after being ſeparated and ſet at Liberty by Diſſolution, is here deſcribed and ſhewn.———Did they amongſt them all compoſe but one kind of figure, however ſimple, with Conſtancy and Regularity, we ſhould declare it wonderful: What muſt we then ſay, when we ſee every Species working as it were on a different Plan, producing Cubes, Rhombs, Pyramids, Pentagons, Hexagons, Octagons, or ſome other curious Figures peculiar to itſelf; or compoſing a Variety of Ramifications, Lines, and Angles, with a greater Mathematical Exactneſs than the moſt ſkilful Hand could draw them?

Senſible of my own Ignorance, I pretend not to account how this is done: all I know is, that Chance or Accident cannot poſſibly produce Conſtancy and Order, nor inert Matter give Activity and Direction to itſelf. When therefore theſe Particles of Salts are ſeen to move in Rank and File, obedient to unalterable Laws, and compoſe regular and de-

determined Figures, we muſt recur to that Almighty Wiſdom and Power which planned out the Syſtem of Nature, directs the Courſes of the Heavens, and governs the whole Univerſe.

The Experiments here deſcribed, and which the Reader is inſtructed to make, muſt I think generally entertain; but merely to entertain, is, I hope, the leaſt of their Worth. They may poſſibly lead to the Knowledge of what paſſes in the Formation of Gems, and the moſt beautiful mineral Productions: And as every new Diſcovery is an Encouragement to farther Diſquiſition, the Hints here given may perhaps ſet abler Heads at Work to improve Art on the Principles of Nature. Examinations by the Microſcope, in the Manner here directed, may likewiſe be employed to aſcertain the Truth and Purity of many ſimple Subſtances and Compoſitions made uſe of in Medicine, and detect Fraud and Impoſition.

The minute living Animals exhibited in the ſecond Part of this Work, will excite a conſiderate Mind to admire in how ſmall a Compaſs Life can be contained, what various Organs it can actuate, and by what different Means it can ſubſiſt. They will alſo ſhew that the Hand which made them is not confined to Size or Form; and that it has not been wanting to beſtow on Creatures almoſt inviſible, and ſeemingly inconſider-

able, every Member and Faculty convenient to their Happineſs.—But this is an endleſs Subject, with which I ſhall detain you no longer than to obſerve, that were there wanting Proofs of a DEITY, they might here I think be found in great Abundance.

Your Lordſhip's great Condeſcenſion and Goodneſs, in honouring this Work and its Author with your Patronage, muſt always be remembered and acknowledged with the utmoſt Gratitude, by,

My LORD,

Your Lordſhip's much Obliged

and moſt Obedient

Humble Servant,

HENRY BAKER.

PREFACE.

'TIS hoped the Book now publiſhed will be accepted favourably by the Curious, and particularly by thoſe acquainted with the uſes of the Microſcope, as it opens to their View an almoſt inhauſtible Store of Objects for that Inſtrument; and many who are Strangers to it, may, 'tis likewiſe hoped, be excited by what they read here, to lend ſome Attention to ſuch of Nature's wonderful Productions as cannot be known without it. The earneſt Wiſh and Deſire of the Author is, that all People would ſee with their own Eyes, and determine by their own Judgment; neither raſhly diſbelieving what is here related becauſe it may ſeem ſurprizing, nor lazily giving it Credit on his bare Word without making Experiments themſelves.

As many of both Sexes who have not had the Advantage of a learned Education, are notwithſtanding greatly deſirous of Knowledge; for the Sake of ſuch, this Treatiſe is written in Terms moſt eaſy to be underſtood; and a ſhort Account of the ſeveral Subſtances here examined is given for their Information.

He

He begs Pardon of the Phyſicians and Chemiſts, for encroaching now and then on their Province, in the Courſe of the following Obſervations and Remarks; and hopes they will generouſly excuſe any Miſtakes he may have fallen into, as he is neither Phyſician nor Chemiſt. Thoſe too who are themſelves well acquainted with the Subjects here deſcribed, will not, he hopes, be diſpleaſed at his endeavouring to inſtruct ſuch as know them not.

He acknowledges his Obligations to many ingenious Friends, who have favoured him with their Obſervations from Time to Time, ſeveral of which are inſerted in this Work; and ſhall always be thankful to any Gentleman who will ſend him an Account of whatever he thinks remarkable.

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EMPLOYMENT

FOR THE

MICROSCOPE, &c.

CHAP. I.

Concerning the CONFIGURATIONS *and* CRYSTALS *of* SALTS *and* SALINE SUBSTANCES.

AS I wiſh nothing more heartily than the real Advancement of uſeful Knowledge, by diſcovering, as far as poſſible, the Operations of Nature in the Formation of Bodies, and their Effects on one another: and as the moſt reaſonable Way of accounting for their Effects muſt ariſe from a Diſcovery and conſideration of the Figure, Size, Solidity, Weight and Motion, of their

conſtituent Parts; ſince we do not, I think, ſuppoſe Body to act on Body by any other Principles *: I have long imagined, that if by an eaſy and natural Separation of ſuch their conſtituent Parts, it were poſſible to know the comparative Size and Figure, Solidity and Motion of the Particles compounding Bodies, when ſo ſeparated from one another; and if we could alſo learn in what Order and Figure they naturally come together, and re-unite after ſuch a Separation, it might lay a Foundation whereon ſome able Builder may erect a valuable Superſtructure,

With this View I have been making Experiments, almoſt continually, for above ten Years paſt, on a great Variety of Saline Bodies, Mineral, Vegetable and Animal, as well as many other Subſtances, both ſimple and compound, whoſe Parts can be diſſolved in Fluids, after a Method which has never hitherto been deſcribed by any Author, or practiſed before myſelf by any body that I have heard of. And tho' I have found their original Particles undiſcoverable by any Microſcope, the Time I hope has not been wholly miſemployed; ſince I have been enabled, by the help of that Inſtrument, to behold the amazing Order and

* Unleſs the new diſcovered Properties of *Electricity* be imagined owing to ſome Cauſes we are not yet acquainted with.

and Regularity, wherewith, after being ſeparated by Diſſolution, they come together and re-unite under the Eye, when put in Action by certain Degrees of Heat, in Configurations appropriated to each of them reſpectively, and with a Conſtancy that is ſurpriſing.

That particular Notice, wherewith the ROYAL SOCIETY was pleaſed to honour thoſe Experiments †, encouraged me to proſecute them with all the Care in my Power, to minute down every remarkable Circumſtance in the Proceſs, and to make faithful Drawings of each Configuration.

Much has been already publiſhed by ſeveral curious Obſervers concerning the Cryſtalizations and regular Figures of Salts, and none I hope will imagine I am hereby endeavouring to deprive them either of their Diſcoveries or their due Praiſe. But I preſume

† After many repeated Examinations of Salts and Saline Subſtances by the Help of Glaſſes, in the Winter of the Year 1743, I had the Honour twice of entertaining the ROYAL SOCIETY with a View of their Configurations, which were then thought ſo extraordinary, that very many of that illuſtrious Body came often afterwards to ſee them more at Leiſure at my Lodgings; and in the Year 1744, Sir HANS SLOANE, Bart. late Preſident of that Society, was pleaſed, at the Recommendation of his worthy Succeſſor MARTIN FOLKES, Eſq; and of the Council of the ſaid Society, to beſtow on me the Medal of Gold, annually preſented (as the Donation of Sir GODFREY COPLEY, Bart. of which Sir HANS is the only ſurviving Truſtee) to whomſoever of their Members ſhall be deemed to have produced the moſt extraordinary Diſcovery during the whole Year.

ſume my Experiments go a great deal farther, both as to the Manner of Examination, and the Variety of Subjects examined: for by the Aſſiſtance of Heat, which in a greater or leſs Degree is perhaps a conſtant Agent in all the Operations of Nature, very different Configurations and Effects are produced than what can be cauſed without it, and our Information is thereby rendered much more compleat and perfect.

To give one ſingle Inſtance of this, which takes place equally in moſt other Subjects: The Cryſtals of Alum are well known, and their Figures (when a Solution of it is permitted to cryſtalize quietly and of itſelf) have been truely deſcribed and pictured by others to be octaëdra, conſiſting of hexangular, triangular and quadrangular Planes: but nobody I believe has before diſcover'd, at leaſt nobody hitherto has informed the World, that the Particles of Alum, when ſeparated by Diſſolution, and excited to Action by a certain Degree of Heat, ſo arrange themſelves as to compoſe regular and delightful Star-like Figures of different Sizes, many whereof have long ſtreaming Tails and reſemble Comets: that it ſhoots forth in ſome Places Figures like Paliſadoes, and in others an almoſt infinite number of parallel Lines, moſt exquiſitely ſtrait, exact and fine; ſome croſſing others at right Angles, and compoſing an Appearance beyond

beyond Deſcription beautiful. *Vide Plate* III. No. I. Indeed the Production of the Star-like Figures depends on a certain Nicety in the Heat continued for a certain Time, which one is not always ſure to hit preciſely; and therefore, though they appear very frequently, they are not quite ſo conſtant in every Trial as its other Configurations; but I doubt not Practice and Obſervation will render them ſo in Time.

I muſt beg leave to call theſe Arrangements of the Particles by the Name of Configurations, thereby to diſtinguiſh them from the Cryſtalizations mentioned by others, whereto they bear little or no Reſemblance. Cryſtalizations ſeem pròduced by a Tendency or Attraction of the Saline Particles towards certain Points, about which they combine in regular and determin'd Forms, according to their reſpective Kinds. Configurations owe their Shapes moſt probably to different Fits of Repulſion and Attraction, (thoſe two wonderful Principles which occaſion moſt of the Changes in Nature) taking place at certain Intervals and in certain Proportions, and operating according to Rules that are conſtant and uniform, though little known to us at preſent. Or if, to make the Subject underſtood the better, I may be permitted to fetch a Compariſon from a common Suppoſition, without examining whether it

be true or falſe, Cryſtalization is like the retiring of the Sap into the Roots of Trees at the Approach of Winter, where during the cold Seaſon it remains dormant and unactive: Configuration reſembles what reſults from the Expanſion of the ſame Sap at the Return of Spring, when excited to Action by the Sun's genial Warmth, it puſhes every Way, exerts its vegetative Force, and becomes productive of Buds, Leaves, Branches, Bloſſoms and Fruits. But the Drawings of one and the other compared together and conſidered, will render this Difference more intelligible than all the Words in Language.

The beautiful Regularity and Order always obſervable in the Works of Nature, are no where more evident than in the Experiments I am mentioning; where the inviſible Particles of Matter, though diſunited by a Menſtruum, and removed to Diſtances from each other, are no ſooner excited to Action than they mutually aſſiſt one another to compoſe Figures peculiar to their ſeveral Kinds, with as much Certainty and Uniformity as Seeds of the ſame Plant produce Plants like one another, not indeed preciſely as to the Number or Poſition of their Branches, Leaves or Flowers, but in the general Growth and Faſhion, and thoſe other Particularities whereby each Species is diſtinguiſhed.

Our

Our Eyes are continually accuſtomed to ſee the Productions of Nature when finiſhed, or brought a conſiderable Way towards it; and what contemplative Man can behold them without Admiration and Delight! but in theſe Experiments we are inabled, by the Aſſiſtance of Glaſſes, to view her actually at Work, forming under our Eyes, and in a few Minutes, Bodies ſo exquiſitely beautiful that nothing but Seeing can give any juſt Idea of them; and that too with ſuch a Variety, as to the Plan and Faſhion of each Kind, as is abſolutely unconceiveable.

Deſcriptions of the Subjects here treated of would be unintelligible without the Aſſiſtance of Drawings. Drawings therefore have been made, and Copper Plates engraven, at no ſmall Expence, of the different Configurations hereafter mentioned: which, though greatly deficient in Beauty and Regularity, if compared with the Originals, and only pretending to give ſuch a general Reſemblance as may diſtinguiſh each Kind from other, will 'tis hoped prove ſatisfactory to thoſe who ſhall pleaſe to repeat the Experiments after me: for however ſtrange they may appear, they are no fanciful Repreſentations produced by the Strength of Imagination, nor are they taken haſtily from one or two Trials, but truely ſhew what generally preſented in

great Numbers of repeated Obſervations. Their Figures are indeed ſo extraordinary, that I ſhould not dare to have laid them before any body, much leſs to have publiſhed them, were there not many Gentlemen of unexceptionable Credit who are living Witneſſes of their Truth, and was I not alſo able, almoſt at any Time, to produce Configurations like thoſe they were taken from.

Theſe conſtant and regular Workings of Nature, which the Microſcope diſcovers, may poſſibly conduct us a Step farther into her Receſſes, and aſſiſt us to judge of Cauſes and Effects in many Caſes where at preſent we are greatly at a Loſs, ſince according to Dr. *Woodward* †, "the Steadineſs and Conſtancy of Nature in all its "Productions, and in the Formation of all "Bodies, happens from the Conſtancy of the "Procedure of the Agents that are inſtrumental to the Formation of thoſe Bodies, "and from the Unalterableneſs of the Corpuſcles which ſerve for conſtituting and "compoſing of thoſe Bodies." And we are told by the Rt. Rev. Author of *Syris* ‡, that the "Analogy, Conſtancy and Uniformity in the Phænomena or Appearances of Nature are a Foundation for general Rules: and theſe are a Grammar for "the Underſtanding of Nature, or the Series "of

† Vid *Woodward*'s Nat. Hiſt. of Foſſils, *Eng. Edit.* Vol. I. p. 186. ‡ Sect. 122.

" of Effects in the viſible World, whereby " we are inabled to foreſee what will come " to paſs in the natural Courſe of Things."

As there is good Reaſon therefore to expect, that the following Experiments may conduce ſomething towards accounting for many Cauſes and Effects in Nature, when duely conſidered by People of true Judgment, to ſuch I freely ſubmit them; without pretending any thing more myſelf than barely to relate Facts: but ſhould they ſerve no other Purpoſe than to preſent a new Set of Objects for the Microſcope, full as wonderful and entertaining as any that have ever been yet examined, affording by Mixture a Variety almoſt infinite, eaſily procured, and always ready for Obſervation, there are many I flatter myſelf to whom they will prove acceptable. And I ſhall endeavour to aſſiſt as much as poſſible the Curioſity of thoſe who may be inclined to repeat theſe Experiments after me, by deſcribing in the plaineſt Terms each Circumſtance neceſſary to be known, either previous to, or during the Time of Obſervation by the Microſcope, and dare aſſure them for their Encouragement, that the Trouble is very little, though the Pleaſure and Information reſulting therefrom is great.

To begin then with the Manner of preparing theſe Subjects for Obſervation.

CHAP.

CHAP. II.

The Method of preparing SALTS *and* SALINE SUBSTANCES, *for the viewing their* CONFIGURATIONS.

I Diſſolve the Subject to be examined in no larger a Quantity of River or Rain Water than I am certain it is ſufficient to ſaturate. If it is a Body eaſily diſſolvable I make uſe of cold Water, otherwiſe I make the Water warm, or hot, or even boiling, according as I find it neceſſary. After it is perfectly diſſolved, I let it reſt for ſome Hours, till, if overcharged, the redundant Saline Particles may be precipitated, and ſettle at the Bottom, or ſhoot into Cryſtals; by which means I am moſt likely to have a Solution of the ſame Strength at one Time as at another; that is, a Solution fully charged with as much as it can hold up, and no more; and by theſe Precautions the Configurations appear alike, how often ſo ever tryed: whereas if the Water be leſs ſaturated, the Proportions at different Times will be ſubject to more Uncertainty; and if it be examined before ſuch Separation and Precipitation of the redundant Salts, little more will be ſeen than a confuſed Maſs of Cryſtals.

The Solution being thus prepared, I take up a Drop of it with a Gooſe Quill, cut in Faſhion

Faſhion of a Scoop, and place it on a flat Slip of Glaſs of about three Quarters of an Inch in Width, and between three and four Inches long, ſpreading it on the Glaſs with the Quill, in either a round or oval Figure, till it appears a Quarter of an Inch or more in Diameter, and ſo ſhallow as to riſe very little above the ſurface of the Glaſs. When it is ſo diſpoſed, I hold it as level as I can over the clear Part of a Fire that is not too fierce, or over the Flame of a Candle at a Diſtance proportionable to the Degree of Heat it requires, (which Experience only can direct,) and watch it very carefully, till I diſcover the Saline Particles beginning to gather and look white, or of ſome other Colour, at the Extremities of the Edges. Then (having adjuſted the Microſcope beforehand for its Reception, armed with the fourth Glaſs, which is the fitteſt for moſt of theſe Experiments,) I place it under my Eye, and bring it exactly to the Focus of the Magnifier, and after running over the whole Drop, I fix my Attention on that Side where I obſerve any Increaſe or puſhing forwards of cryſtaline Matter from the Circumference towards the Center.

This Motion is extremely ſlow at the Beginning, unleſs the Drop has been overheated, but quickens as the Water evaporates, and in many Kinds towards the Concluſion produces Configurations with a Swiftneſs uncon-

unconceiveable, compoſed of an Infinity of Parts, which are adjuſted to each other with an Elegance, Regularity and Order, beyond what the exacteſt Pencil in the World guided by the Ruler and Compaſſes can ever equal, or the moſt luxuriant Imagination fancy.

When Action once begins, the Eye cannot be taken off, even for a Moment, without loſing ſomething worth Obſervation: for the Figures alter every Inſtant till the whole Proceſs is over; and in many Sorts, after all ſeems at an End, new Forms ariſe, different entirely from any that appeared before, and which probably are owing to ſome ſmall Quantity of Salt of another Kind, which the other ſeparates from and leaves to act after itſelf has done: and in ſome Subjects three or four different Sorts are obſervable, few or none being ſimple and homogeneous.

When the Configurations are fully formed, and all the Water evaporated, moſt Kinds of them are ſoon deſtroyed again by the Moiſture or Action of the Air upon them; their Points and Angles loſe their Sharpneſs, become uneven and defaced, and moulder as it were away. But ſome few are permanent, and by being incloſed between Glaſſes, as I ſhall direct hereafter, may be preſerved Months, or even Years, entertaining Objects for the Microſcope.

N. B.

N. B. It happens oftentimes that a Drop of a Saline Solution can hardly be ſpread on the Slip of Glaſs, by reaſon of the Glaſs's Smoothneſs, but breaks into little Globules, as it would do were the Surface greaſy; this was very troubleſome, till I found a way of preventing it, by rubbing the broken Drop with my Finger over the Glaſs, ſo as to leave the Glaſs ſmear'd with it; on which ſmear'd Place when dry, another Drop of the Solution may be ſpread very eaſily in what Form one pleaſes.

It likewiſe ſometimes happens, that when a heated Drop is placed properly enough for Examination, the Obſerver finds he can diſtinguiſh nothing: which is owing to Saline Steams that riſe from the Drop, cover and obſcure the Object Glaſs, and therefore muſt immediately be wiped away with a ſoft Cloth or Leather.

'Tis I think an allowed Maxim, that Salts act not unleſs in a State of Diſſolution, for which Reaſon I diſſolved them in order to obſerve their manner of acting. A certain Degree of Heat is likewiſe moſt commonly employ'd by Nature in all her various Productions: wherefore I imagined that by the Aſſiſtance of Heat, applied in different Degrees, I might in ſome ſort imitate Nature, and produce ſuch Figures as Salts are thrown into, not when they ceaſe to act, which I apprehend is the Caſe when they

are

are formed into Cryſtals, but even whilſt they are acting: and this what I call their Configuration does moſt wonderfully ſhew.

My Intention was to diſcover as far as might be, the natural Inclination, Progreſſion and Figure of each reſpective Salt under Examination; it was conſequently neceſſary to avoid making uſe of any Diſſolvent, which by containing other Salts might create Confuſion, and produce Forms not conſtant or eſſential to the Subject of Inquiry. River or Rain Water has therefore moſt commonly been my Diſſolvent, being what I judged leaſt likely to prejudice my Experiments. I am very ſenſible neither Salts or other Bodies are to be obtained unmixt and perfectly homogeneous: but I have taken pains to procure ſuch of each Kind as appeared moſt pure and perfect, I mean of the ſimple Salts; as for the Compounds I was obliged to rely on the Chemiſt.

In all Examinations by the Microſcope of Saline Solutions, even though made in the Day-time, I always employ the Light of a Candle, and adviſe every Obſerver to do ſo likewiſe: for the Configurations being exceedingly tranſparent, are rendered much more diſtinguiſhable by the brown Light a Candle affords, than by the more white and tranſparent Day-light; and beſides, either by moving the Candle or turning the Microſcope, ſuch Light may be varied

varied or directed juſt as the Subject requires.

It may be alſo proper to take notice, that no Kinds of Microſcope are fit for theſe Obſervations, but ſuch as have an open Stage, whereon the Slips of Glaſs with the Liquor upon them may be placed readily, and in a perfect horizontal Poſition; and moreover where they can be turned about freely, and without diſordering the Fluid. Thoſe Microſcopes where Sliders or Slips of Glaſs are thruſt in between two Plates, as in *Wilſon*'s, &c. be they in whatever Direction, cannot therefore properly be employed here.—The following Obſervations were all made by a double Microſcope, conſtructed by Mr. *Cuff*, in *Fleet-ſtreet*, with ſome Regard to theſe Experiments. Its Figure reſembles what is called commonly the *Double Reflecting Microſcope*, and like that it receives Light from a Speculum underneath: but beſides an Improvement in the Poſition of the Glaſſes, its Stage is diſencumbered with Legs, and quite open for the Reception of Objects without Trouble; its Motion is not by Jerks, as in the Microſcope juſt now mentioned, but regulated by a fine-threaded Skrew, whereby it is adjuſted to the Eye with great Eaſe and Exactneſs: and all that try it will I believe judge it not only the moſt convenient Microſcope for this Purpoſe, but likewiſe for gene-

ral Uſe. Wherefore as this Inſtrument, which has been conſtructed ſince the Publication of the *Microſcope made eaſy*, could not be given there amongſt the other Microſcopes then in uſe, I intend at the End of this Treatiſe to inſert a Drawing and ſhort Deſcription of it.

CHAP. III.

Of SALTS *in general.*

IT ſeems neceſſary in order to make the Matter in Hand underſtood the better, that ſome Account be given of what is meant by *Salts* and *Saline Subſtances*, together with ſome ſhort Explanation of the Diſſolution of ſuch Subſtances, and their Cryſtalization afterwards; whereby the Difference between my Experiments and thoſe of others may become more evident.

Few will I preſume imagine, that I mean by Salts ſuch Subſtances only as afford what is called a Salt Taſte; for Salts are of all Taſtes, and Sugar itſelf is no other than a Salt extracted from the Sugar Cane. But we underſtand by Salts, all Subſtances whatſoever that are diſſolvable in Water, or whoſe Parts become ſo ſeparated thereby as to diſappear therein; which, notwithſtanding

ing the Water being evaporated, ſhew themſelves again combined in ſome ſort of angular Forms, with a Degree of Tranſparency, and to the Taſte are more or leſs pungent. To this may be added, that they are fuſible by Fire.

Salt, thus underſtood, is one of the firſt Principles of the Chemiſts; and indeed has good Reaſon to be eſteemed ſo, as it enters into the Compoſition of all Bodies. It is every where, and in every thing: for if any Stone, Plant, or Animal be burnt, a Salt remains in the Aſhes, which may be extracted by Water, and ſeparated from the Caput Mortuum.

It is the Nutriment of Animals, Vegetables and Minerals, inſomuch that Herbs, Roots, Bread, &c. deprived of their Salts, can neither ſuſtain, nouriſh, or increaſe the Bodies of Animals; and the Earth when diveſted of it becomes abſolutely barren.

Vegetables and Animals, whilſt flouriſhing and alive, diſcharge by Perſpiration and other more ſenſible Evacuations the Exceſs and Recrements only of the Salts whereby they are preſerved: but when they periſh, the Chain whereby the Parts were kept together becomes broken, the Salts regain their Liberty by Putrefaction, ſome fly away into the Air, and the reſt remain in a Condition to enrich and render fertile

that lean and hungry Earth which is deſtitute of ſuch Salt.

Taſtes, Smells, and moſt other Effects of Bodies on one another, ſeem occaſioned by the Action of Salts, which by ſtriking on our Organs produce Senſations correſpondent to their Figures, and by the ſame means affect all other Bodies.

Being tranſparent, and having a ſtrong attractive Power, they probably ſupply both Matter, Conſiſtence and Form to Spars, Cryſtals, Diamonds, and all other Gems and pellucid angularly figured Foſſils. When combined and at Reſt they are perhaps the Baſis of Coheſion and Solidity in moſt Bodies, the Pegs or Nails that hold the Parts of other Matter together; but when put into Motion by the Separation of their component Particles, and their repulſive Force (which is no leſs vigorous than their attractive Power) becomes exerted, they are the moſt active Principles in Nature, like Knives or Launcets cut their Way through every thing, and produce the moſt ſurprizing Changes. Whence the Chemiſts ſay, that in the Sun and in Salt are all Nature's Productions; and, that he who knows not Salts, will never perform any thing in Art.

The Diſtinction of Salts into acid and alkaline, into volatile, fixt, and eſſential, I ſhall leave the Reader to conſult chemical Writers about.

CHAP.

CHAP. IV.

Of Dissolution.

THE Diſſolution of Salts or ſaline Bodies is effected by an Intruſion or Interpoſition of the Particles of Water, or ſome other Diſſolvent, between the Particles that compound ſuch Bodies; whereby their Combination is deſtroyed, and they become ſeparated from each other.

Sir *Iſaac Newton* † accounts for the Diſſolution of ſuch Subſtances from the great Principle of Attraction, and the Manner thereof is explained by Dr. *Friend*, in his *Prælectiones Chemicæ*, p. 61, where he gives a mechanical Deſcription of the diſſolving of common Salt in Water; the meaning of which in few Words is, "that the "Corpuſcles of Salt being extremely ſimple, "minute, and ſolid for their Bulk, are con-"ſequently indued with a ſtrong attractive "Power: (Attraction being, *cæteris paribus*, "always in proportion to the Quantity of "Matter:) the Particles of Water are there-"fore attracted more vigorouſly by the ſa-"line Particles than by one another: for the "watery Particles cohering but ſlightly, and "moving readily, when they approach the "Particles of Salt, ruſh as it were into their "Embraces; and opening a Paſſage into their

 "Pores,

† Vid. *Newton*'s Opticks, p. 351.

" Pores, which are very numerous, the Tex-
" ture and Coheſion of their Parts become
" intirely broken and deſtroyed, the Corpu-
" ſcles are ſeparated, and float here and there
" in the Warer."

Water (or ſome other Liquor) having thus inſinuated between the component Particles of ſaline Bodies, deſtroyed their Coheſion, and removed them from each other; if the minute diſunited Particles are fewer than what the Interſtices of the Water can contain, they remain ſuſpended in the Fluid, though being extremely ſmall and tranſparent the Eye cannot diſcern them; for notwithſtanding Salts are ſpecifically heavier than Water, their minute Particles, when ſeparated, having their Surfaces increaſed in proportion as their Bulk is diminiſhed, are unable to overcome the Reſiſtance of the Fluid, and conſequently cannot ſink therein. But if the ſaline Particles are more in Quantity than the Interſtices of the Water can eaſily contain, the Reſidue attract each other, form little Maſſes heavier than the Fluid, and either fall to the Bottom, or adhere to the Sides of the Veſſel, and that moſt commonly in the Form of regular Cryſtals.

CHAP.

CHAP. V.

Of CRYSTALIZATION

THE uſual Way of procuring Cryſtals from any Salt or ſaline Subſtance is, to diſſolve the ſame in warm Water; to filter the Mixture if there be any Foulneſs; to evaporate till a Film is ſeen at Top; and then to ſet it in a cool Place to ſhoot. Heat enables the Water to diſſolve and hold up a greater Quantity of the Salt than it would do without it, and Cold afterwards greatly aſſiſts its forming into Cryſtals.

The Cryſtals thus formed, whether more or leſs in Quantity, will always have ſuch Figure as is peculiar and conſtant to the Kind of Salt they are procured from; and how often ſoever their Particles be ſeparated by Solution, they will come together again, and reunite in ſuch a Manner as to produce Bodies exactly of the ſame regular Forms; which muſt imply, that ſuch component Particles, whatever their Shape or Texture be, are themſelves unalterable, and that the Principle or Law whereby they are brought together is uniform and perpetual. Their Concretion may be accounted for on Sir *Iſaac Newton*'s Principles, by the attractive Force with which all Bodies, and Salts more eſpecially, by reaſon of their Solidity, are indued; whereby, when the Water wherein they float

is evaporated to ſuch a Degree that the ſaline Particles come within the Reach of each other's attractive Power, and do actually attract one another more vigorouſly than the Fluid attracts them, they form themſelves into Cryſtals. And as to the Regularity of their Figures, "that argues (according to the ſame great Man) that "the Particles of the Salt before they con- "creted, floated in the Liquor at equal "Diſtances in Rank and File; and by "conſequence that they acted upon one "another by ſome Power which at equal "Diſtances is equal, at unequal Diſtan- "ces unequal. For by ſuch a Power they "will range themſelves uniformly, and "without it they will float irregularly, and "come together as irregularly." He alſo ſuppoſes, "that the Particles not only range "themſelves in Rank and File for concret- "ing in regular Figures, but alſo by ſome "kind of polar Virtue turn their homo- "geneal Sides the ſame Way †.

As that Conſtancy of Figure, obſervable in the Production of Cryſtals from the ſame Salt, proves their component Particles to have ſome determined and unalterable Shape, ſo the Difference of Figure peculiar to the Cryſtals of different Salts, induces one to believe, that the component Particles of each Kind differ no leſs in Shape

† *Newton*'s Opticks, 2d Edit. Page 363.

Shape from the Particles of every other Kind than the Cryſtals they compoſe do.

The Particles of them all are indeed ſo exquiſitely minute, that no human Eye or Inſtrument can poſſibly diſcern them, being finer, in ſeveral Kinds, even than the Particles of Air, forcing their Way through Metals, Glaſs, and other Bodies, where the Air can find no Entrance. Conjectures have notwithſtanding been made concerning their Figures; ſome ſuppoſing them exactly of the ſame Shape in little, as the Cryſtals they conſtitute by their Combination are in a larger Size; whilſt others inſiſt, that their Shape is intirely different from what appears in the Cryſtals; the Figures whereof ariſe, as they imagine, from a ſtronger Attraction on ſome Sides of the ſame Particles than on others, whereby the Concretions on thoſe more attractive Sides are greater: for, ſay they, if the Particles of Salt that ſwim in a Fluid attract each other mutually, and by their Figure have a greater attractive Power in ſome Parts than in others, and if their Contact be greateſt in thoſe Parts, ſuch Particles will form themſelves into Bodies with given Figures, or, in other Words, will conſtitute regular Cryſtals.

That ingenious mathematical Profeſſor and Phyſician of *Bononia* *, *Dominicus*

* Vid. *Diſcorſo ſopra le Figure de' Sali.* Printed at Bologna 4to. 1688.

Gulielminus obſerves, that the ſenſible Cryſtals of any Salt, however large or minute they may be, have always the ſame Figures: the Co-ordination of the Parts not depending on the Quantity of the component Matter: that Nitre, for Example, in its Efflorescencies from Walls, diſpoſes itſelf into very ſlender Bodies of the like Figure exactly as its larger Cryſtals; and that not only Cryſtals too ſmall for our Eyes to ſee, but even the minuteſt Particles of their Salt, that were diſſolved in the Water before their Cryſtalization, have the ſame Figure as the larger Cryſtals have. Whence he ſuppoſes the firſt Principles of Matter whereof the Salt is compoſed, and which on Account of their Smallneſs no Force can poſſibly divide, to have ſuch determined Figures, as they can never change, impoſed on them at their Creation. And for this he quotes Mr. *Leeuwenhoek*, who aſſerts, that in Solutions of *Cyprian* Vitriol, and of Tartar, he has ſeen Particles, which though not larger than the twenty thouſandth Part of the Thickneſs of a Hair, were exactly figured like their larger Cryſtals; and thoſe Figures in two or three Minutes increaſed to an hundred times their former Bulk, ſtill retaining their Figure, however they were enlarged in Length and Breadth.

Nor does he imagine any other Cauſe for

for the Separation of a Salt from the Fluid wherein it is diſſolved, but an Inclination of the Planes of the ſmalleſt Particles to unite; which Inclination being alike in all, they join one after another on every ſide: by which means the Size grows larger, but the Figure alters not. Thoſe in common Salt he affirms to be minute Cubes, in Vitriol Parallelopipids, and in Nitre hexagonal Priſms.

Hence he infers, that the Figures of the Cryſtals prove not only the Exiſtence and Shape of their component Particles, but withal demonſtrate that the Cryſtals are themſelves produced by an appoſite Union of ſuch-like figur'd Particles, whoſe Figures cannot be deſtroyed unleſs by Annihilation.

That the moſt minute Cryſtals diſcernable by the Microſcope may be obſerv'd growing under the Eye, and enlarging their Dimenſions many thouſands of times without an Alteration in Figure, I dare affirm from my own Experience: but I pretend not thereby to determine the real Shape of the original Particles of any Salt, or to underſtand the other Properties concerned in their Combination. After all my Experiments, I am too ſenſible of my own Ignorance to ſet up any Hypotheſis: that I leave to abler Judges on future Tryals; begging Leave inſtead thereof to ſubmit the following Queries to be conſidered at Leiſure.

QUE-

QUERIES.

DO not Attraction and Repulsion seem to be the principal active Powers whereby the natural Changes in Bodies are produced?

Are not these Powers inherent, probably, in all Matter, however their Agency may be suspended, diminished, augmented, or otherwise diversifyed?

May we not suppose, that by the first of these Powers the original Particles of Matter be brought together and conjoyned, in the Formation of most compounded Bodies? and does not the Destruction of such Bodies, or the Separation of their component Particles, seem probably greatly owing to the Latter?

Is there not Reason to believe, that the Particles of Matter constituting Gold, Stone, Wood, Flesh, *&c.* are different from each other *ab Origine*; and, consequently, that there are different Kinds of simple material Particles?

Must not these Particles (however unconceivable their Minuteness be) have some determined Figures and Sizes? May not such Figures and Sizes be different, and indued with different Degrees of the attractive or repulsive Force: and may not the Difference in Bodies as to Coherence,

Soli-

Solidity, Duration, &c. be owing to the various Intermixture and Combination of Particles either *alike*, or *unlike* in Size and Figure †?

May there not be a Kind of *Polarity* in the original Particles? or, may they not attract at ſome Points and repel at others, and that in various Proportions, according to their Inclination towards each other, their Diſtances, their Points of Contact, or other Circumſtances? May not ſuch Attraction or Repulſion be excited, or ſuſpended, by Heat, Cold, Motion, Reſt, &c.? And as Light has alternate Fits of eaſy Reflexion and eaſy Tranſmiſſion ‡, occaſioned by the different original Properties of the different Sides of its Rays *, (as Sir *Iſaac Newton* has

† "All the Phænomena in Nature are produced by Motion. There appears an uniform working in things great and ſmall by attracting and repelling Forces. But the particular Laws of Attraction and Repulſion are various. The minute Corpuſcles are impelled and directed, that is to ſay, moved to and from each other, according to various Rules or Laws of Motion. Some Bodies approach together, others fly aſunder, and perhaps ſome others do neither. When Salt of Tartar flows *per deliquium*, it is viſible that the Particles of Water floating in the Air are moved towards the Particles of Salt, and joined with them. And when we behold vulgar Salt not to flow *per deliquium*, may we not conclude that the ſame Law of Nature and Motion doth not obtain between its Particles and thoſe of the floating Vapours? A Drop of Water aſſumes a round Figure, becauſe its Parts are moved towards each other: but the Particles of Oil and Vinegar have no ſuch Diſpoſition to unite." *Vide* Biſhop of CLOYNE's *Syris*, Page 110.

‡ NEWTON's Opticks, Page 339. Again, 347.

* Ibid. Quere 26.

has ſhewn:) may there not alſo be alternate Fits of eaſy Attraction and eaſy Repulſion, occaſioned by the Conjunction, or Oppoſition, of the attractive or repulſive Sides in the Particles of Matter? May not the Succeſſion of ſuch Fits be extremely quick, as in the Vibrations of Bodies, *&c.*? and may they not be prevented, diminiſhed, circumſcribed, augmented, propagated, or communicated with almoſt infinite Variety (as to the Modification) according to the Conſtitution of the Bodies wherein they are excited, and the Aptneſs or Unaptneſs of other Bodies near them?

May we ſuppoſe the Attraction and Repulſion of Magnetiſm, Gravity and Electricity, to be different Powers, or different Modifications only of the general attractive and repulſive Power ſuppoſed reſident in all Matter?

Do not Heat and Motion ſeem moſt likely to excite Repulſion; and are not Cold and Reſt moſt favourable to Attraction?

When the Particles of Subſtances evaporate, become volatile, or fly away, is not ſuch Volatility owing to the repulſive Force of the Particles, ſome how or other put into Action? And is not the Exploſion of Gunpowder, *&c.* occaſioned probably by a Fit of Repulſion, excited ſuddenly and violently by Fire, in the component Particles of the Gunpowder?

Sup-

Suppoſing that Salts are diſſolved, or their Parts ſeparated, (according to Sir *Iſaac Newton*'s Theory, and the beforementioned Explanation of Dr. *Friend*,) becauſe the Particles of Water are more ſtrongly attracted by the Particles of Salt than by one another, and ruſh between and diſunite the ſaline Particles: may not the repulſive Power of the ſaline Particles, as to one another, be exerted at the ſame Time? or may not a Fit of Repulſion inſtantly ſucceed the former Fit of Attraction *? And, if the repulſive Power be of equal Force in each of the Particles, will they not be repelled to equal Diſtances from each other, and conſequently be diſpoſed in Rank and File: and when their next Fit of Attraction takes place, will they not unite according to their Arrangement, and conſtitute regular Figures?

Without ſuppoſing ſuch Fits of Repulſion and Attraction, will it not be very difficult to conceive, how the Particles of Salt, which, notwithſtanding their mutual Attraction and Contact, became ſeparated each from other by their ſtronger Attraction

* Unleſs by ſome ſuch means, it is not eaſy to imagine that the Particles of Water ſhould be able to enter the Interſtices between the conſtituent Particles of Salts: for the firſt Particles of Salts are found to be ſmaller even than thoſe of Air, by their paſſing through Cork, Glaſs, and other Bodies, which Air cannot paſs through, and conſequently their Interſtices muſt be ſtill much ſmaller.

on of the Particles of Water, ſhould afterwards, when carried to Diſtances from each other, where their mutual Attraction muſt be rendered much weaker, forſake the Particles of Water (which they had attracted and joyned themſelves to ſo ſtrongly) come together again, and combine more firmly than they did before *; for Cryſtals are not near ſo eaſy to diſſolve as Salts before they are cryſtalized?

Does not the Power of Attraction increaſe as the Diſtances between the Particles decreaſe? Is it not of great Strength, when they are brought in Contact? and would not moſt Bodies be abſolutely ſolid, and their Parts almoſt inſeparable, was not Hardneſs an eſſential Property in Matter, which (by rendering the Particles incompreſſible) prevents their Contact otherwiſe than in Points, and occaſions numberleſs Pores or Interſtices between them?

May not the attractive and repulſive Power be in proportion to the Surface rather than the Solidity, (as it is found in Magnets,) and in Conſequence thereof, are not the ſmalleſt Particles indued with the ſtrongeſt Attraction and Repulſion?

If

* When a Glaſs Tube, made Electrical by rubbing, attracts a downy Feather, ſoon afterwards repels it, and drives it continually away until the Feather has touched ſome other Body; after which it immediately attracts, and then repels it; have we not a plain ocular Demonſtration of alternate Fits of Attraction and Repulſion?

If the Particles of Matter have Sides and Angles, will they not touch in more Points, and form Bodies more ſolid and durable when joyned together laterally, than when connected by their Angles? And if the Surfaces of ſuch Bodies are ſmooth and poliſhed, will not their Junction be much the firmer?

When one Salt is ſaid to be converted into another, or appears in the Figures of another, by the Addition of ſomething thereto; may it not be ſuppoſed, that by the Intervention of other ſhaped Particles, the Particles of the firſt Salt are prevented from cohering by the ſame Sides and Angles as they did before: and that by the Mixture of theſe Figures the new Forms are produced?—Some Solutions will mix and form Cryſtals and Configurations by Combination: in others, however blended, the Cryſtals of each Kind appear always ſeparate,

Are not tranſparent Bodies compoſed probably of homogeneous Particles, or Particles of the like Size and Figure, arranged in ſome uniform Direction, whereby their Interſtices being rendered regular, are fitly adapted for tranſmitting the Rays of Light? And is not the Tranſparency of all ſaline Cryſtals and Configurations moſt likely to be owing to the ſame Cauſe?

Do not the Colours of Bodies alſo depend on the Arrangement of their Particles, for the more or leſs ready Reflexion, Refraction, Tranſmiſſion, or Retention of the Rays of Light?

CHAP. VI.

Directions for making a Collection of the Solutions of SALTS *and* SALINE SUBSTANCES, *and preſerving them always in Readineſs to be examined by the Microſcope.*

AS the Curious may be deſirous to collect and keep by them the ſeveral ſorts of Salts mentioned in this Treatiſe, whereby they may at any time amuſe themſelves or entertain their Friends at a Moment's Notice; I ſhall put them in a Way that will intirely anſwer this Purpoſe, founded on my own Experience.

Let a Drawer or Box be made three Inches in Depth, ten Inches wide, and fourteen Inches long in the Clear: at about an Inch and a quarter from its Bottom place a thin Board of the exact Length and Width of your Drawer, horizontally, on four little Pillars faſtened in the Corners; this Board having firſt of all round Holes cut through it, in Rows, of a Size to receive Glaſs Phials that hold one Quarter

of

of an Ounce, and ſufficiently large for them to go eaſily in and out. Such a Board will conveniently admit of twelve Rows, each Row having eight Holes.

Being thus furniſhed with a Repoſitory for your Collection, and provided with ninety-ſix Phials of clear Glaſs to place in theſe Holes, where they will ſtand in order without Danger of tumbling down or being otherwiſe diſplaced, put into each Phial as much of any Salt or ſaline Subſtance, reduced to Powder, as you are certain will be ſufficient to ſaturate about half the Quantity of Water it can contain; for 'tis beſt to prepare no more at once, as thereby you will leave room for making Mixtures and trying Experiments, which if the Bottles are quite full you cannot do ſo well. Then with a Tea-ſpoon, half fill your Phials with boiling Water, immerging them all the while up to the Neck in a Baſon of Water, likewiſe boiling hot †, and hold them there till the Salt is all diſſolved, or you are ſure the Water will diſſolve no more.

This done, faſten with ſtiff Paſte a ſmall Piece of Paper on the Side of each Phial near the Neck, that it may eaſily be ſeen; having previouſly marked the Papers 1, 2, 3, 4, 5, *&c.* in a numerical Order. Fit

 the

† Cold Water or warm Water will do for ſome ſorts, but hot Water does no harm to any, and is beſt for moſt.

the Phials with good ſound Corks, on which you muſt likewiſe mark the ſame Numbers, that you may not miſtake the Bottles they belong to: and do not think it enough to mark the Corks only, for many of the Salts will deſtroy the Marks upon the Corks, and by that means leave you in the Dark as to what they contain, unleſs there are Papers alſo marked, to help you out.

Make then an exact Catalogue of them, ſetting down each Particular under a *Number* correſpondent to that on the Bottle it is in; whereby you will at any time find readily whatever Solution you want to examine. You may range your Bottles in what Order you think fit: that in this Treatiſe is perhaps as good as any.

Theſe Preparations will keep good many Years; and when any Phial is almoſt out it may eaſily be repleniſhed, ſo as to preſerve your Collection always compleat. You muſt not expect to fill all your Bottles immediately; forty or fifty ſorts will be perhaps as many as you will ſoon be able to procure; and therefore, if you ſhall be ſatisfied with them, your Box may be contrived in the above Manner to contain only ſome ſuch Number. But a diligent Enquirer will be able to add to them from Time to Time, and would not willingly be limited in his Reſearches. Suppoſe however

ever you have only forty Sorts; by different Mixtures and Compoſitions of them with one another, you may produce many thouſands of Subjects for Examination, and be continually diſcovering new and wonderful Configurations: from this rich Store, by combining different Salts, and in different Quantities, innumerable Varieties may be formed, as from the different Arrangements of the twenty-four Letters of the Alphabet, all the Sounds of Language may be ſignified.

Here is an unbounded Field, which I only point out to the Curious, without deſcribing the Beauties I have frequently met with in my Rambles there. 'Tis enough for me to ſhew the Configurations and Cryſtals of Salts ſimply and ſingly; I recommend to thoſe who have more Leiſure, to examine them all differently combined.

Solutions thus prepared will be always ready to ſhew the Configurations forming under the Obſerver's Eye; a Sight no one can behold without Admiration and Delight. It would likewiſe be very deſirable to preſerve the Configurations themſelves, after they are compleat and perfect, or in their different Stages: but this in general cannot be done, for much the greater Part of them are broken and deſtroyed by the Air ſoon after they are produced. A few however are durable, and may be kept a

long while in good Perfection, if another Slip of Glaſs, of the ſame Length and Breadth, be placed over that the Configurations are formed upon, with the Interpoſition only of a very thin Slice of Cork between them at each End, to guard the Configurations, by keeping the Glaſſes aſunder, from being any ways rubbed or damaged. A little Glew, ſtrong Gum, or ſticking Paſte, applied to each Side of the Slices of Cork, will faſten the Glaſſes ſo well together as to make of them a ſort of Boxes or Caſes, including the Configurations, and defending them from any Injury, if the open Sides be ſhut up, by paſting a narrow a Slip of Paper over them: but then Pin-holes muſt be made through the Paper; for if the Air be intirely excluded, the Configurations will ſoon decay.

I have now by me ſeveral of theſe little Caſes of Glaſs, containing Configurations and Cryſtals that appear nothing at all the worſe for keeping, though they have been prepared at leaſt four Years. Theſe are always ready to ſhew in a Minute, without any farther Trouble, and are a very pretty and curious Set of Objects. The Glaſſes for them are all cut by the Glazier of the ſame Size exactly, *viz.* one Inch and three Quarters long, and almoſt an Inch broad. They muſt be free from Scratches, Flaws, or Air Bubbles.

The

The Salts whoſe Configurations or Cryſtals may be thus kept, are *common Salt* of ſome kinds, not of all: *Alum*, ſome of the *Vitriols*, *Saccharum Saturni*, *Ens Veneris*, *Salt of Amber*, and ſome others, which are eaſily known by their not breaking or diſſolving away ſoon after they are produced.

CHAP. VII.

A general Explanation of the PLATES, *with ſome farther Thoughts on the Cryſtals and Configurations of Salts.*

HAVING declared already what I mean by Configurations, and given a full Account how to prepare ſaline Subſtances for that Purpoſe, and to makea proper Collection of them, little more is requiſite at preſent than to explain briefly what the following Plates deſign.

Each Figure repreſents a Drop of the Solution of that Subſtance whoſe Name it bears; and is calculated to ſhew the Proceſs of its Appearances, from the firſt beginning to cryſtalize about the Edges, to the full and compleat Concluſion of all its ſeveral Changes.

As Heat excites Action, and ſets the ſaline Particles in Motion, thoſe Particles, whilſt

floating in a heated Fluid, may be ſuppoſed to have a conſiderable Liberty of exerting their attractive and repulſive Properties, as they approach each other in their Fits of Repulſion or Attraction; or according to the fortuitous Appoſition or Approach of their attractive or repulſive Points each to other; whence a Commotion muſt neceſſarily ariſe, ſome attracting and others repelling, till ſuch time as the Particles can diſpoſe themſelves in the Order and Figure that muſt neceſſarily reſult from their original Forms and Properties: which Forms and Properties being ſuppoſed unalterable, how often ſoever they are diſſolved or ſeparated, they will conſtantly unite again in the very ſame Manner *. And accordingly, in many of the following Solutions innumerable little Maſſes may be diſcovered, hurrying about moſt violently, and in all Directions, before there appears the leaſt Tendency towards ſhooting into regular Figures.

The Solution being more ſhallow, and the Attraction greater, about the Edges of the Drop than near its Middle, the floating Particles of Salt tend towards the Edges in great Abundance, and begin there, moſt com-

* Should the Particles wear away, or break in Pieces, the Nature of Things depending on them would be changed. Water and Earth compoſed of old worn Particles and Fragments of Particles, would not be of the ſame Nature and Texture now, with Water and Earth compoſed of intire Particles in the Beginning. *Newton*'s Opticks, p. 376.

commonly, to combine in ſuch Cryſtals as are peculiar to the Subject; the Side and Angles of which Cryſtals formed within the ſurrounding Fluid are regular, poliſhed, and tranſparent: and their oppoſite Sides would be the ſame alſo, were they not terminated by the Edges of the Drop, and unable to form themſelves upon the dry Glaſs.

This uſually is the Beginning of the Proceſs; and thus far the Power of Attraction ſeems almoſt wholly to prevail: a Power whereto Cryſtalization appears almoſt intirely owing; Repulſion, on the contrary, may be deemed the firſt Agent in producing Configurations: or to ſpeak more plainly, Attraction, by making all the Particles within a certain Circumference move towards ſome certain Points, and combine together in a regular Order, produces Cryſtals; Repulſion, by puſhing them outwards from ſome certain Points, in a regular Order, occaſions Configurations, when they are brought together again by Fits of Attraction.

Should it be objected, that our Configurations may alſo be produced by Attraction only, I muſt preſume to think that is ſcarcely poſſible; for the Shoots that firſt appear do not only puſh forwards vigorouſly in the Proceſs, but divide and ſubdivide into innumerable Lines and Branches; which

Diviſion and Subdiviſion ſeem directly contrary to the Effect of an attractive Power; ſince Attraction can hardly be ſuppoſed to make Particles of the ſame homogeneous Matter ſeparate. I am however inclinable to believe, that the Fits of Repulſion, which puſh out the aforeſaid Lines and Branches, may be attended or immediately ſucceeded by Fits of Attraction, laterally, in the Particles compoſing them; whereby the intermediate ſaline Particles diſperſed in the Fluid between the ſaid Lines and Branches are attracted to the Sides, combine with, and become a Part thereof. For was it otherwiſe, when the Fluid is quite evaporated, Particles of Salt would be found between the Lines, which they are not in any Quantity. Such a Propulſion forwards and Attraction ſideways, at, or nearly at the ſame Inſtant of Time, may eaſily be imagined, if we ſuppoſe two oppoſite Sides of the ſaline Particles indued with an attractive, and two other oppoſite Sides of the ſame Particles indued with a repulſive Property, in ſome ſuch Sort, as every Ray of Light is conſider'd by Sir *Iſaac Newton*, in his Obſervations on the double Refraction of Iſland Cryſtal, as having * four Sides or Quarters, two whereof oppoſite to one another incline the Ray to be refracted after one Manner, and the other two oppoſite Sides incline the Ray to be refracted after a different Manner.

Cryſtals

* *Newton*'s Opticks, p. 334.

Cryſtals and Configurations are frequently ſeen together in the ſame Drop, and forming at the ſame Inſtant. As ſoon as the Cryſtals become diſcernable by the Microſcope, they are either Cubes, or Rhomboids, or Columns, or pyramidal, or triangular, or ſome other certain Figures; and to what Bigneſs ſoever they may become inlarged, they ſhew, from their very firſt Appearance, the ſame Sides and Angles that are ſeen afterwards when at their utmoſt Size, no Alteration of Figure attending their Increaſe in Bulk. But the Configurations change their Forms every Moment, puſhing forwards in new Shapes continually, and leaving no Reſemblance of the Forms that preſented firſt: inſomuch, that no better gueſs can be made (in a Subject never before examined) what Configuration will be form'd thereby, from ſeeing its firſt beginning Shoots, than from ſeeing the Germen or ſeminal Leaves of an unknown Seed one can paſs a Judgment what other Leaves, Flowers and Fruit ſuch unknown Seed ſhall produce.

From the firſt puſhing forward of the Salt there is a continual ſeeming progreſſive Motion and Change of Figure*: but as

* Notwithſtanding this Manner of Expreſſion, in Conformity to the Appearances of Things, I ſuppoſe the Configurations of Salts are produced according to certain Laws of Repulſion and Attraction, whereby the floating Particles

as Motion can not be pictured, I have endeavoured to ſupply that Defect, by repreſenting, in ſeveral Parts of the ſame Drop, the different Stages or Appearances that are moſt remarkable during the whole Proceſs, and by giving a particular Account thereof in the Deſcription.

The cryſtaline Shoots that preſent about the Edges of the Drop demand our firſt Examination; and it is adviſable from their very Beginning to keep the Eye conſtantly fixt upon them, and to obſerve their Growth. In ſome Subjects the Configurations puſh out from theſe Cryſtals into an Infinity of regular Branchings; but in others, and thoſe eſpecially of the mineral Kind, the Cryſtals ſhooting from the extreme Edges into the ambient Fluid preſerve themſelves ſeparate and entire, even through all the Changes that happen, and by their Tranſparency

cles of ſuch Salts become arranged in certain determiued Figures, according to their reſpective Kinds, by Juxta-poſition, Accretion or Appoſition, and not by any Protruſion or ſhooting forwards in the Manner of the Growth of Plants. And therefore though *growing*, *ſhooting out*, *branching*, *protruding*, and ſuch like Terms, are frequently made uſe of in the Courſe of this Treatiſe, in order to avoid Circumlocution, and to render the Subject more familiar; the Reader is deſired to take Notice and remember, that ſuch like Expreſſions are not to be underſtood literally in the ſtrict Senſe of the Words, as ſuppoſing any thing ſimilar to Vegetation; any more than among People well ſkill'd in Aſtronomy the Sun is ſuppoſed actually to move from Eaſt to Weſt, to riſe in a Morning and to go down at Night, though they frequently ſpeak of its moving ſo, of its riſing, and its going down, in conformity to common Appearance.

parency and poliſhed Sides and Angles, bear a near Reſemblance, when enlarged by the Microſcope, to the Shootings (in the Fiſſures of Rocks and Mines) of Spars, Cryſtals, and ſeveral Kinds of angular and figur'd Gems, and ſerve moreover to point out after what Manner ſuch Bodies are alſo probably formed in a ſurrounding Fluid *, and poſſibly too of ſimilar Materials: for there ſeems nothing unreaſonable in ſuppoſing, that different mineral Salts, diſſolved in ſome Fluid exſuding from Rocks or Mines, and tinged with metalline Matter, may, through the wonderful Chemiſtry of Nature, ſupply the different Subſtance, Hardneſs and Colour of Spars, Cryſtals, and precious Stones; in ſome ſuch like Way as their Reſemblances are produced from the Solutions of ſuch Salts ‡. Nor are the Hardneſs of precious Stones, their being void of any ſaline Taſte, and their

* Cryſtals and all angular Bodies concrete in the Midſt of a reſolvent Fluid or Menſtruum. The Fluid wherein Cryſtal is concreted, is to Cryſtal as common Water is to Salt. (*Steno*'s *Prodromus*, Eng. Edit. Page 64.) That is, the Cryſtal Particles are ſeparated and float in ſuch Fluid, as the Particles of Salt do, when diſſolved in common Water.

‡ Mines, or Beds of Metal, are met with conſtantly, if ſought after, near the Places where precious Stones are found. The Ruby is ſuppoſed by ſome to take its Teint from Gold, by others from Iron; the Emerald and Sapphyre from Copper, but by different Menſtrua; the Topaz from Lead or Iron, Granates from Iron, &c. and a Mixure of two or more Teints from different Metals may poſſibly give Colour to the Amethyſt, the Hyacinth, the Opal, &c. A greater or leſs Proportion of metalline Matter may alſo render the Gem deeper or paler, harder or ſofter.

When

their Indiſſolubility, ſufficient Objections againſt Salts being the Baſis of Diamonds, Rubies, Emeralds, Granates, *&c.* ſince it is obſervable, that Glaſs, in whoſe Compoſition Salt is a principal Ingredient, proves alſo undiſſolvable, is indued with a conſiderable Degree of Hardneſs, and (as its component Salts cannot act unleſs diſſolved) is conſequently inſipid, or rather abſolutely taſteleſs.

Whoever ſhall pleaſe to repeat theſe Experiments after me, will I believe be ſatisfied, that the Cryſtals ſhooting from a Solution of diſtilled Verdigreaſe, which is a Vitriol loaded with Copper; thoſe Cryſtals I mean whoſe Roots are at the Extremity of the Drop, and their Points in the ambient Fluid, reſemble nearly the ſhootings of Emeralds both in Figure and Colour: that the Cryſtals of *Ens Veneris*, a Preparation of Iron, wonderfully emulate the Topaz, *&c.* No

When the ſaline Particles combine, without any metalline Admixture, the Concrete appears colourleſs, and probably forms pure Cryſtals or Diamonds. The extreme Hardneſs and Luſtre of the Diamond reſult perhaps from the almoſt abſolute Homogeneity and Purity of its component Particles; whoſe Sides or Planes having admitted no foreign Particles between them, touch in many Points, and become thereby almoſt inſeparable. Saline Particles in ſuch Purity meet, however, but very ſeldom, and in ſmall Quantity: but as mineral Salts abound almoſt every where, and eſpecially about Rocks and Mines, they frequently appear in Shoots or Maſſes, blended more or leſs with talcky or other Matter, and probably conſtitute our Cryſtals, Spars, *&c.*

No Kinds of Matter that we know of, except Salts, have a Tendency to ſuch-like Figures: but Salts when at Liberty always appear in them. The Tranſparency of Salts is alſo another Property almoſt peculiar to themſelves and the Bodies we are ſuppoſing them to compoſe: and therefore, notwithſtanding in theſe our haſty and imperfect Experiments the Shoots are ſo minute as to require a Microſcope to diſcern them, and ſo tender that the Air in a ſhort Time deſtroys them, may not Nature, who proceeds ſurely, though ſlowly, produce Bodies from a better Combination of the ſame Kinds of Materials, of Size proportionable to the Quantity of ſuch Materials, ſimilar in Figure and Colour, hardly ſeparable and of long Duration?

I have dwelt the longer on this firſt Part of the Proceſs (which the Drawings point out in the Shootings of *diſtilled Verdigreaſe*, Plate II. 1, 1: in thoſe of *Alum*, Plate III. *b b:* and of *Ens Veneris*, Plate IV. *a a*) ſince every Obſerver muſt be highly pleaſed, to behold the beautiful Appearances of Emeralds, Diamonds, *&c.* riſing as it were from their native Bed, forming their regular Sides and Angles under his Eye, and glittering with a Brilliancy and Colouring hardly to be imagined.

What has been hitherto deſcribed regards the Figures only that proceed from

and

and ſeem rooted to the very Extremity of the Drop.——The detached Cryſtals that appear forming within the ſame come next under Examination: and theſe, from their very firſt becoming diſcernable, being encompaſſed on every Side by a Fluid replete with ſaline Particles, (which, ſwimming at Liberty, are attracted or repelled from every Quarter, till the Points of greateſt mutual Attraction meeting in Contact, combine according to their reſpective Figures †:) Theſe, I ſay, have all their Sides moſt commonly regular and compleat, with ſuch Number and Diſpoſition of poliſh'd Planes and Angles as fully diſtinguiſh from what Salt they are derived.—Theſe are the Cryſtals that were before mentioned to retain their Figure however their Size inlarges: They, and they alone, are properly to be termed the Cryſtals of ſuch Salt, and many of them in Elegance of Form and native Luſtre excel the Workmanſhip of the moſt expert Jeweller. Theſe are intended to be repreſented in the *Alum* Solution at *f*, and in that of *Ens Veneris* at *b b*. They are alſo ſhewn again by themſelves, and in a larger Size, under thoſe and ſome of the other Drawings.

After

† All foſſil Cryſtals, Gems, and other Bodies that have regular Planes and Angles, without an Appearance of being broke off from any Root or Stem, are probably formed in the ſame Manner.

After the Cryſtals about the Edges are grown large, and thoſe farther within the Drop have likewiſe pretty nearly attained their full Size; in the Solutions I mean where ſuch Cryſtals do form; for ſeveral Kinds produce Configurations but no Cryſtals; and, on the contrary, in ſome few, *viz.* of Sal Gem, common Salt, *&c.* though abundance of Cryſtals are produced, no Configurations at all appear: After, I ſay, the Cryſtals are formed, the Configurations begin to ſhoot, proceeding ſomewhat ſlowly at the firſt: but they quicken by Degrees, and dart at laſt, in many Subjects, quite over the whole Drop, as ſwift as Lightning; and that eſpecially if the Drop has been too much or over ſuddenly heated. Therefore when the Configurations once begin, the Eye ſhould never be taken off, till they are intirely finiſhed. Some Deſcription of them is given under each particular Subject, and they are repreſented in the Drawings, as the third Stage of the Proceſs, ſignified by *c*, D, *e*, F, G, in the *Alum* Drop, and by *c* and *d* in the Drop of *Ens Veneris*.

Theſe Configurations are no leſs conſtant in their Forms than the Cryſtals are, inſomuch that each Subject is eaſily diſtinguiſhed by them. They ſeem compoſed likewiſe of the ſame tranſparent ſhining Particles: but the Figures they produce

are ſo extremely different, that every conſiderate Obſerver muſt judge them owing to ſome very different Property in Nature.—I have ventured to mention Attraction and Repulſion, as two Principles that we may ſuppoſe concerned in producing theſe different Appearances, but am very far from being obſtinate in this Opinion, or unwilling to recede from it, whenever any more probable Cauſe can be aſſigned. I am ſufficiently ſenſible how liable we are to be miſtaken, and how very little we know even of the moſt common Things. The very Elements that are continually about us, the Fire, the Water, the Air we breathe, and the Earth we tread upon, have many Properties beyond our Senſes to reach, or our Underſtanding to comprehend: and when we imagine we know any one thing perfectly, I am afraid we flatter and deceive ourſelves very groſly. It is our Happineſs, however, and our Duty, to beſtow ſome Time and Pains in making ourſelves acquainted with the Productions and Changes that Providence continually brings about in a regular and conſtant Manner. We are able to ſee Effects, though their Cauſes are beyond our Knowledge: but as no Effect can be produced without ſome Cauſe, when we behold Order, Harmony, and Beauty ariſe out of Confuſion, by means of certain active and unalterable Properties, where-

wherewith the Author of Nature has indued the original Particles of Matter; though we cannot underſtand the mechanical Operation of theſe Properties, or know really what they are or can perform, we ſhould raiſe our Contemplations and Adoration to that Eternal, Omnipotent, Supreme Firſt Cauſe, who is incomprehenſible in all his Works: and here, perhaps, here only, our Ignorance may commendably become the Mother of our Devotion.

In ſhort, if the Cryſtals of ſaline Subſtances are wonderful, their Configurations are infinitely more ſo, : their Variety and Beauty no Words or Language can poſſibly expreſs; and trying to give the Pictures of them is like endeavouring to paint the Luſtre of a Diamond, or the Brightneſs of the Sun-ſhine.

It happens in ſome Kinds of Solutions, that after the firſt Cryſtals are formed, the Configurations perfected, and when every thing ſeems over, and all is quiet, other new Configurations, and Cryſtals too, preſent themſelves, in Figures very different from the former, and what probably are owing to Salt of another Kind that was latent in the Mixture.

CHAP. VIII.

Of Gem-Salt, Sea-Salt, and Spring-Salt.

GEM-Salt diſſolved in warm Water, and a Drop applyed to the Microſcope on a Slip of Glaſs, either holding it over the Fire for a little while to haſten the Experiment, or leaving the Water to evaporate at leiſure, affords the ſeveral Figures that appear in the firſt PLATE N° I.

Sea-Salt treated in the like Manner produces Cryſtals as at N° II.

The Figures of *Spring-Salt*, or * *Baſket-Salt*, obtained by the ſame Method, are ſhewn at N° III.

The Figures of theſe three Salts differ very little; each of them producing Bodies of the like Forms; *viz.* ſolid Cubes, ſquare Plates, and hollow Pyramids, having Baſes that are either exact Squares, or Rectangles, and whoſe ſloping Sides diminiſh gradually upwards by a kind of Steps, ſome terminating in a Point, and others appearing truncated, or ending with plane Surfaces. Each Kind of theſe Salts does not however produce the ſame Figures in equal Plenty, for *Gem-Salt* affords moſt Variety; *Sea-Salt* abounds chiefly with thoſe

* This does not mean that all Salt made from Springs is *Baſket-Salt*, but only that our *Baſket-Salt* is one kind of Salt made from Springs.

theſe two Figures N° II. and *Spring-Salt* with thoſe at N° III.

Moſt Writers repreſent the Cryſtals of theſe Salts as Cubes; and ſuch in Truth they ſeem originally to be: I mean when ſo minute as juſt to become diſtinguiſhable by the greateſt Magnifier: large Maſſes of *Sal-Gem*, and ſometimes of *Sea* and *Spring-Salt* are ſeen in cubical or rectangular Figures, made up without doubt of innumerable minute Cubes. But in all Examinations by the Microſcope of the Solutions of theſe Salts, the Bodies that form and grow under the Eye are, in the general, not Cubes, but hollow Pyramids: though a Prepoſſeſſion that the Cryſtals of ſuch Salts are Cubes, makes theſe Figures, even under Inſpection, often imagined ſo to be: for the ſquare Out-line, which is only the Baſe of an hollow Pyramid (if great Attention be not employed) is apt to give the Idea of a Cube: and the different Ranges or Steps, which by a gradual Diminution upwards compoſe the ſloping Sides of the Pyramid, are eaſily miſtaken, from their great Tranſparency, to be no other than Lines upon the Surface of the Cube. Indeed a few Cubes are ſeen now and then amongſt the other Forms, but their Number is far too ſmall to conclude the general Figure from: thoſe very Cubes in ſome Poſitions have

likewiſe the Appearance of regular Hexagons, as in PLATE I. N° I. *l.*

I have examined various Species of theſe Salts from different Parts of the World, and particularly ſeveral brought from *Egypt*, *Hungary*, *Germany*, *&c.* by my worthy and ingenious Friend Dr. *Richard Pocock*, Archdeacon of *Dublin*, and F. R. S. which tho' red, brown, white, *&c.* and ſeemingly of very different Contexture, ſome appearing fibrous, others ſparry, talcky, *&c.* yet when diſſolved and examined, much the greateſt Part of the regular Bodies produced in them all were of the ſame general Figure, *i. e. hollow Pyramids;* with little farther Difference, than that ſome were more tranſparent and ſharper at the Top than others. It may therefore reaſonably be concluded, that an hollow Pyramid, either pointed or flat, is the general Figure of all *Foſſil*, *Sea* and *Spring-Salts*, when after being diſſolved, and a ſmall Degree of Heat given, their Particles are brought together, and unite again according to the Order and Diſpoſition of Nature: which hollow Pyramid is compoſed of minute Cubes moſt regularly and wonderfully combined *. And this has been demonſtrated even

* Dr. *Bownrigg* obſerves, in his very curious Treatiſe of the *Art of making Common Salt*, p. 67. That when by a very gentle Exhalation of Water from common Salt, it is

even to the naked Eye by the Salt made after Mr. *Thomas Lowndes*'s new Method, where Multitudes of ſuch regular pyramidal hollow Bodies may be found, compoſed as it were of a Number of little Stairs; and ſo large, that each Side of their ſquare Baſe is at leaſt a Quarter of an Inch in Length †.

None of theſe Salts afford any Branchings out: the Appearances round the Edges of the Drop, when Heat is apply'd, being nothing elſe but a Congeries of ſaline Particles hurried together with very little Regularity, and producing no new Forms: for which Reaſon theſe Combinations are not repreſented in a Drop, as all that ſhoot into Figures more different are. But notwithſtanding the general Shape of theſe Bodies is nearly the ſame, there are particular Differences very well worth obſerving, which the *Drawings* endeavour to expreſs.

is ſuffered to ſhoot into its true Form, its Cryſtals are found of a cubical Figure of various Sizes: and many of theſe ſmaller Cryſtals are united together into hollow Pyramids with a ſquare Baſe. Theſe Pyramids are truncated, being not finiſhed at the Top, but having there fixed a Cube of Salt of a more than ordinary Bigneſs.

† Mr. *Lowndes* ſays "in the Salt made by the Sun, as "well as by my way, you will never fail of ſeeing very "many little Pyramids, which are compoſed of a Parcel of "ſmall cubical Grains piled up in a moſt exact Order, and "cemented together with wonderful Nicety: and the "Crowns of theſe Pyramids are always Cubes of a much "larger Size than any of the reſt." Vid. *Brine Salt improv'd*, p. 16.

PLATE I. N° I.

Figures of SAL-GEMMÆ, *or* ROCK-SALT.

a - A ſquare pyramidal hollow Body, ſomewhat opake, whoſe four Sides are ſloping Triangles, and meet in a Point at Top.

b - A Body with four equal ſloping Sides, terminated by a Plane at about half the Height of the former: not much tranſparent, but hollow.

c - A Body riſing about the Height of the laſt, in the Manner here ſhewn, and very tranſparent, except as the Lines imply.

d - A ſquare thin Plate, exceedingly tranſparent.

e - An hollow Pyramid, whoſe Baſe is a Rectangle, and whoſe Sides are ſloping and terminate in a Point; the whole ſemi-tranſparent.

f - A narrower hollow Rectangle, with ſloping Sides not much tranſparent, riſing about half as high as the preceding, and then ending in a flat Surface that is very tranſparent.

g - Another hollow Figure, having a rectangular Baſe, very tranſparent, with ſloping Sides as in the Picture.

h—An

h - An hollow Body, whoſe Top is a large tranſparent Square, and whoſe Sides are darkiſh in the Middle, but very tranſparent at the Ends, whereby the four Corners become alſo tranſparent.

i - A very pretty tranſparent truncated pyramidal Figure, whoſe Top is alſo a tranſparent Square, and whoſe four Corners appear to open and ſeparate.

k - A ſolid Cube, ſemi-tranſparent.

l - Another Cube, which by its Poſition, if careleſly examined, will probably be miſtaken for an Hexagon.

m - A ſquare Plate of ſome Thickneſs, but tranſparent: its Situation makes it ſeem a Rhombus.

nn - Two oblong Plates, extremely thin and tranſparent, with a Spot in the Midſt of each.

PLATE I. N° II.

Figures of SEA-SALT.

o - A ſquare Pyramid, hollow, and pretty tranſparent, wherein a Kind of Steps appear gradually leſſening upwards.

p - Another Figure about half the Height of the preceding, whoſe Top is a very tranſparent ſquare Plane, and whoſe four ſloping Sides are graduated and conſiderably tranſparent.

PLATE I. N° III.

Figures of SPRING-SALT.

After the Deſcriptions already given, 'tis needleſs to ſay more of the four following Figures *q*, *r*, *s*, *t*, than that they alſo are hollow pyramidal tranſparent Bodies, with ſuch different Graduations as themſelves pretty tolerably repreſent.

v, *w*—Two of the large hollow Pyramids of Mr. *Lowndes*'s Salt, drawn in ſuch a perſpective View as may beſt expreſs their real Figure; each having a ſquare Baſe, and four triangular Sides that are nearly equal. Many fine Lines appear running acroſs theſe Sides parallel to the Baſe, which on a ſtrict Inſpection, are found to be a regular Graduation of Steps, leſſening from the Bottom upwards. Theſe Pyramids do not commonly end in Points, but are terminated by a cubic Figure: each Corner of their Baſe is alſo frequently ſupported by a Cube, but of a ſmaller Size; and ſtill leſſer Figures of the ſame Shape appear along the linear Edges, in number equal to the Steps, and cloſing the Angles where they join. There are Graduations within-ſide theſe Pyramids correſpondent to thoſe without, like the Underwork of a Pair of Stairs. The Size here exhibited is but

but little larger than that of the real Bodies they were drawn from.

It is very well worth remarking, that amongſt the many pyramidal Figures preſenting themſelves in a Drop of the Solution of theſe Salts, every one ſeems to ſtand erect upon its hollow Baſe, and appears, when under Inſpection by the Microſcope, exactly in the ſame Manner repreſented in the Plate: but this is a Deception; for in double Microſcopes compounded of three convex Claſſes after the uſual Manner, all the Parts of an Object are ſeen inverted; that is, the Top appears at Bottom, the left Side on the right, *&c.* The Lights and Shades being alſo inverted, the ſinking Places appear to riſe, and the riſing Places to ſink in: ſo that in Truth the hollow Baſe of the Pyramid is really uppermoſt and next the Eye, tho' it ſeems to be quite otherwiſe. And in Confirmation of this, I was aſſured by Mr. *Lowndes*, that in the making his Salt, nothing is more common than to ſee the Pyramids forming upon the Surface of the Brine, and always with their truncated Ends downwards *.

We

* We are told in the *Memoirs of the Royal Academy of Sciences* for the Year 1700, that Monſieur *Homberg* ſhewed a little Pyramid of Salt, formed in a Cryſtalization. It was but low in Proportion to its Baſe, hollow within, and its Baſe was uppermoſt during the Time of its Formation; which Monſieur *Homberg* thus accounts for. There was formed, ſays he, at firſt, a little Cube of Salt (the Figure Salt naturally affects) on the Surface of the ſalted Water.

This

We begin our Experiments with that native fossile Salt, usually called *Rock-Salt*, from its Place of Growth, and from its Clearness *Sal-Gem*; as it is probably the Principle or Basis of several other Salts.

Sea Water owes its Saltness most likely to vast Quanitities of this Salt dissolved therein; which being extracted by different Methods, becomes either *Bay-Salt*, or what we commonly call *Kitchen-Salt*: and Springs running through or over Beds thereof, and becoming saturated therewith, afford by Boiling and Evaporation all our Inland or *Basket-*

This Cube did not sink, though heavier than the salt Water, any more than a Needle if laid on Water gently would do, and for the very same Reason; for when a Needle is placed in such a Manner on Water, a little Hollow is made about it, filled with Air only, in which it lies as in a little boat; because the Bulk of the little Hollow and Needle together is lighter than Water of the same Dimensions. A similar Hollow was formed about this Cube of Salt, which entered a little into the Water without sinking; its upper Surface was dry, and rose above the Surface in the Hollow, though not so high as the general Surface of the Water round it. Other Cubes of Salt crystalizing along the four Sides of this dry Surface began to form a small hollow Square, of which the first Cube composed the Base. These little Cubes when joined together, becoming heavier than the first single one, and being encompassed with less Air in Proportion, from their Junction to the first by their inner Sides, sunk still deeper in the Water, that is, to the upper Surface of the little Cubes which adhered to the first Cube. New Cubes of Salt adding themselves to these sunk the Body yet lower down, and others continually joyning them after the same Manner, by enlarging the hollow Square, still plunged it more and more, and formed the inverted Pyramid; which growing at last too heavy, sunk to the Bottom of the Water, and then increased no more.

Baſket-Salt; ſo that, in Reality, *Rock-Salt*, *Sea-Salt*, and *Spring-Salt* are derived from one and the ſame Original in the Bowels of Rocks and Mountains; and upon the ſtricteſt Examination, they ſeem to differ no otherwiſe than by ſome adventitious Mixtures, as our Experiments evince, by ſhewing that neither of them form any branched Configurations; but when their Particles combine again after Diſſolution, they conſtantly compoſe the ſame Kinds of pyramidal Cryſtal Bodies, with Baſes that are either exact Squares with four equal Sides, or elſe having two oppoſite Sides longer than the other two, but always making a right-angled Figure.

This Salt is conveyed by Springs and Rivers where-ever their Waters can find a Paſſage. Its fineſt Particles riſing with Exhalations from the Sea and other Waters, are likewiſe diſperſed univerſally, and ſaturate the Surface of the whole Earth: where entering the Roots of Plants they promote Vegetation, help to compoſe their ſolid Parts, aſcend with their Juices, and, according to their Mixture with them, produce that amazing Variety of Taſtes, Smells, and other Qualities. Some of this may be recovered in its original Form by Art from moſt Kinds of Vegetables, while the reſt becomes ſo changed by being blended with other Subſtances, as to appear in the Shoots

or

or Crystals peculiar to each Sort of Plant, and probably constitutes its *essential Salt*.

It is also taken continually into the Stomachs of Animals, their Food abounding with it, and affording them proper Nutriment by the Means thereof. It dissolves in and circulates with their Blood and Humours, and becomes so highly subtilized by the Heat and Action of an animal Body, that the greatest Part of it is rendered volatile, and can hardly be reduced again into its original Figure, though some of it may always be found unaltered in the Blood, Urine, *&c.* And the Fertility which Dung produces in barren Soils is owing to the Abundance of it contained therein: for though Salt in its natural State is prejudicial to Vegetables, it becomes so tempered after having passed through the Bowels of living Creatures, and been intimately mingled with their putrifying Fæces, that it causes them to thrive exceedingly.

No Menstruum is yet found to dissolve Gold, unless one of the Salts we are treating of be an Ingredient therein; they being the only known Dissolvents of Gold, as Nitre is of Silver: but on the contrary, Common Salt, Rock-Salt, or Spring-Salt, mixed with *Aqua Fortis* or *Spirit of Nitre*, will prevent its dissolving Silver, though such Mixture proves the readiest Dissolvent of Gold.

The

The peculiar Excellence of these Salts for the Preservation of Flesh, Fish, *&c.* is too well known to need Description; and their other extraordinary Virtues, when prepared in different Ways, are too many to be mentioned here. *Glauber* asserts, that common Salt is the most useful and most excellent of all the rest, being the Principle whence all other Salts, either known or unknown, are chiefly derived, and may by Art be produced. By a little Labour and Fire, and the Addition of some metallic Sulphur, it may, he says, be converted into Alum or Vitriol; by Fire, Air, and Sulphur, into Salt-Petre; by the Help of a fiercer Fire, into an alkalious Salt, and by destroying its Acridity, into a Salt fit for inriching Land, and extreamly serviceable to sandy and barren Soils *.

Common Salt dissolved in sharp Vinegar, and a Drop thereof a little heated, shoots some pretty Configurations from the Edges, and affords Crystals of the Figures just now described, extremely clear and beautiful, though smaller than usual. These frequently are joyned together with a curious Variety of Composition, which the Crystals of the same Salt dissolved in Water never exhibit, for they commonly form separate and disposed at Distances from each other.

Dissolved

* Vid. *De Nat. Salium*, Amstel. p. 49.

Diſſolved in Spirit of Wine it likewiſe produces Configurations, but very different from thoſe in Vinegar, with Cryſtals ſmaller than ordinary, and having little or no Tranſparency.

Dr. *Boerhaave* ſays, theſe three Species of Salt diſſolve alike in three Times and a Quarter of their own Weight of Water ‡: but I have found a conſiderable Difference in different Waters, and in different Portions of the ſame Salt.

CHAP. IX.

NITRE, *or* SALT-PETRE.

THIS Salt being diſſolved in Water, a Drop of the Solution ſhoots from its Edges, with very little Heat, into flattiſh Figures of various Lengths, exceedingly tranſparent, and with Sides that are ſtrait and parallel. Theſe are ſhewn in their different Degrees of Progreſſion, at the Letters *a, b, c, d, e,* Plate I. N°. IV. where *a* repreſents how they firſt begin.

Many of them appear cut ſloping at the Ends down to a ſharp Edge, in the Manner of a Chiſſel, and are ſome wider and others narrower. Several alſo are found with

‡ Shaw's *Boerh. Chem. p.* 106. Vol. I.

with one Corner taken off obliquely, and that in different Angles, leaving the other Corner ſometimes quite a Point, and ſometimes having a little Breadth.

After Numbers of theſe are formed, they will often diſſolve again under the Eye and intirely diſappear; but if one waits a little, new Shoots will puſh out, and the Proceſs go on afreſh. Theſe firſt Figures ſometimes inlarge only, without altering their Shape, and ſometimes form in ſuch Sort as the Drop repreſents; but if the Heat has been too great, they ſhoot haſtily into numerous Ramifications, very regular and beautiful, but which we have not attempted to draw, from the great Difficulty of doing it. There ſeems all the while a violent Agitation in the Fluid, and moſt commonly towards the Concluſion, a few Octaëdra (compoſed of eight triangular Planes, or two quadrangular Pyramids joined Baſe to Baſe) appear; which belong probably to ſome other Kind of Salt intermixed with the Nitre: Pyramidal Figures of common Salt are likewiſe ſometimes ſeen; and of theſe I have now and then found the greateſt Plenty when the Nitre has ſeemed moſt white and pure, which I pretend not to account for, unleſs common Salt has been employed to make it ſo.

The regular Cryſtals of Nitre are repreſented underneath the Drop, greatly magnified

nified according to my Method of Examination, though indeed leſs than what may be found when large Quantities are prepared in the common Way; and conſiſt of ſix parallel Sides or Planes, which compoſe Bodies of different Lengths, and differently terminated at the Ends. There is alſo a conſiderable Variety as to the Equality and Inequality of theſe ſix Sides. The moſt common Cryſtals are ſomewhat flat, and have two broad parallel Planes oppoſite to one another, and four that are much narrower; two of which (*viz.* one that goes ſloping from the upper and the other from the under Plane) meet on each Side, and conſtitute a pretty ſharp Edge. One End of theſe is commonly cut off ſloping on both Sides along its whole Breadth, but ſeldom in the ſame Angle. *Vid.* Fig. 1. Sometimes however there are four broader Planes, and only two narrower; and now and then the Sides are pretty equal, and their Baſe is nearly an equilateral Hexagon. The ſeveral Differences in the Drawing are likewiſe to be met with, as well as ſome others, but the rareſt as well as the prettieſt is that at Fig. 6.

The beſt Way to obtain theſe Cryſtals for the Microſcope, is by ſaturating ſome warm Water in a Spoon with Nitre; (not with more however than it can perfectly diſſolve) when in a few Minutes little Concretions will

will be ſeen forming at the Bottom, which being taken up on the Point of a Penknife, before they are grown too large, and placed with a little of the Fluid on a Slip of Glaſs, will be found, if they are not broken by the Removal, to have amongſt them ſome or all of the Figures ſhewn in the Drop, and again repreſented in a larger Manner underneath the ſame. And though the Cryſtals thus obtained are exceeding ſmall, they are much more intire, diſtinct, and true, than what by concreting in vaſt Quantities become Millions of Times bigger, as they are frequently ſeen in the Shops. Amongſt theſe too may be found many Cryſtals perfect at both Ends, by having been formed wholly detached in the ſurrounding Fluid, whereas thoſe we get by any other Method are almoſt conſtantly broken at one End, from their having been fixed thereby to the Side or Bottom of the Veſſel they were formed in, or elſe to one another.

PLATE I. N° IV.

The Cryſtals of Nitre.

1. The moſt common Figure of *Nitre-Cryſtals*, with one End broken off.
2. A Cryſtal with both Ends perfect; one in the uſual Form as above, the other

cut off more obliquely, and compoſing an hexangular Plane. The Sides of this Column are four broader and two narrower Planes, whereas the preceding conſiſted of two broader and four narrower.

3. Another Cryſtal, having one End a great deal ſloping and graduated, and the other cut off at different Angles.
4. A Cryſtal incloſed ſeemingly within another, and forcing its way out, by burſting through the other's Side.
5. A Column with ſix equal or nearly equal Sides: one End broken, and the other forming an hexangular Pyramid, whoſe Sides are correſpondent to thoſe of the Column.
6. A ſhort hexangular equilateral Column, both whoſe Ends are Pyramids, having Sides that correſpond with thoſe of the Column.

One Particularity in Nitre is, that its Cryſtals are perforated from End to End *, all along, juſt within the Corners where the Planes interſect; as may be proved in the larger Shoots, by the Breath's paſſing thro' them eaſily on blowing. Theſe Channels are pointed out in Figure 2, by the ſix Dots at its End; they are likewiſe ſhewn more perfectly at Fig. 7. which repreſents part

* *Gugliel. Diſc. ſopra le Fig. de' Sali*, p. 12.

part of a Column with Hairs paſſing thro' its Perforations.

This Salt is found juſt under the Turf about *Patneſs* in the Northern Parts of the Kingdom of *Bengal*, and probably in other Places thereabouts, whence it is brought to us in great Abundance by the *Eaſt-India Company* *: but all produced in *Europe* appears either like a kind of Efflorescence adhering to Rocks and Walls, being what the Ancients called *Aphronitrum*, and what is called by us *Natural Salt-Petre*, of which the Quantity collected is but ſmall; or is elſe extracted by Art from certain Earths and Stones, the Ruins of old Buildings, the Dung of Pigeons, and the Excrements and Urine of other Animals: the Manner of doing which is related by ſeveral Authors.

Examin'd chemically (and to uſe the Chemiſt's Terms) it appears compounded of a volatile acid Spirit, and a fixt alkalious Salt. Such a Spirit the Air abounds with: and this Spirit by penetrating into, and becoming incorporated and fixt by the alkalious Salts of Lime, and ſome Sorts of Earth and Stone, is probably the active Principle that produces *Salt-Petre*. It is alſo very likely owing to the ſame Principle, that *Salt-*

* Vid. *Woodward*'s *Method of Foſſils*, p. 36.

Petre may conſtantly be obtained from the Mortar and Rubbiſh of old Walls, which have been long expoſed to the Air; and that the ſame Materials, after being diveſted of it by Art, will afford a farther Quantity by lying a few Years together. The extreme Hardneſs of the Mortar in ſome old Buildings, where it is found more difficult to be broken than even the Bricks or Stones it ſerved to cement, ſeems likewiſe occaſioned by its being ſo fully impregnated with this Spirit † or Principle, that it becomes in a manner petrified: and the alkalious Salts wherewith the Excrements of Animals abound, ſerve probably, in the like Manner, to fix and embody the ſame Spirit, and conſtitute *Salt-Petre*. Some have undertaken to make it likewiſe from Lime, Pot-Aſhes, *&c.* but howſoever it be produced, it may always be diſtinguiſhed by its hexagonal Shoots.

Let us now conſider what other Productions of Nature appear in this hexagonal Figure; and we ſhall find that all Cryſtal, unleſs either ſtraitened for Room or

† May not what we call a volatile Spirit conſiſt of Particles exceedingly minute, and of ſome determinate Figure; whoſe Property it is to repel each other, from certain Points, in certain Directions, and to certain Diſtances; whereby they are unable to combine together, unleſs by penetrating, mixing, and becoming embodied with other Matter, whoſe Pores they can ſtrike into? and may not their repulſive Power be increaſed by Heat or Motion?

or overcharged with foreign Matter, is conſtantly formed into Pyramids of ſix Sides, or into hexagonal Columns terminated with ſuch Pyramids, and reſembling the Nitre Shoot 5. And as theſe Cryſtals ſhoot moſt commonly from Rocks of calcarious Stone, may not their Form be owing to the ſame volatile Spirit, more ſtrongly fixed and embodied, and compoſing a more hard and tranſparent Subſtance, by an Admixture with ſome Matter different from that wherewith it compoſes Nitre? And if, inſtead of exſuding from Stones, and adhering thereto by one End, uſually called a Root, theſe Principles happen to concrete in ſome Fluid, or other ſoft Bed, where both Ends are equally at Liberty to faſhion themſelves according to the Inclination of their component Particles, may we not ſuppoſe they may then produce * thoſe ſparry or cryſtaline Pyramids, joyned Baſe towards Baſe by the Intervention of an hexagonal Column which are known by the Name of *Buxton Diamonds*, from the Place where found moſt plentifully; and which in Figure reſemble exactly the Shoot of Nitre 6?

The next moſt remarkable Bodies of this Kind of Figure are thoſe of Snow, which

* Vid. *Woodward's Hiſtory of Foſſils*, vol. I. p. 161. Theſe Bodies are called *Irides* by *Aldrovand.* See his *Muſæum*, p. 941, 942.

are always hexangular, or with ſix Points *, nearly reſembling the Baſe of the Column of Nitre 1, or thin Slices of ſuch a Column cut off tranſverſly: and as freezing is uſually imputed to the Redundance of Nitrous Particles in the Air, thoſe who embrace that Opinion will probably find little Difficulty in ſuppoſing this Form of Snow occaſioned by the ſame Principle that gives an hexagonal Figure to Nitre: and perhaps they are not miſtaken in ſuch a Suppoſition, though there is ſome Reaſon to believe they may be ſo as to the Abundance of the Particles of Nitre they imagine exiſting in the Air.

The continual Perſpiration of growing Vegetables, the Putrefaction and Diſſolution of thoſe that periſh over the Face of the whole Earth, all which abound with volatile acid Salts; the continual Exhalations from Seas, Lakes, Rivers, and other Waters, which carry alſo up with them abundance of the fineſt Particles of Mineral or Sea Salts, the Steams and Vapours from Metals and other Subſtances, all theſe compoſe together the volatile acid Spirit wherewith the Air is filled, and which probably is the active Principle that gives the Figure, and ſupplies Part of the Matter to Cryſtals, Snow, and Nitre.

But

* The Flakes found now and then with twelve Points, are probably two Flakes, whoſe flat Surfaces are ſtuck together, with their Rays alternately diſpoſed.

But the Particles of this acid Spirit are no more the Particles of Nitre, than Nitre is the Gunpowder which it compoſes by the Addition of Sulphur and Charcoal. And the Truth of this ſeems confirmed by the Impoſſibility of obtaining a ſingle Grain of real Nitre from any Quantity of Snow or Ice: whereas Nitre being but little volatile, ſome of it certainly would be found if it was really there. However, though no Nitre can be found, after the volatile Salts that link'd the Particles of Water to one another are driven out by Heat, and the Water becomes fluid, it is obſerved to be much harder, or leſs fit to make a Lather with Soap, than it was before its being frozen, from its retaining ſome ſmall Portion of the acid ſaline Particles, in the ſame manner as any Water may be rendered *hard*, by putting into it a few Grains of common Salt, or a few Drops of any acid Spirit.

'Tis probable theſe acid Spirits are produced every where; but being extremely volatile, and eaſily driven away by Heat, they ſoon become diſſipated in thoſe hot Regions, under, or nearly under the Sun's direct Rays, unleſs they are immediately embodied by mixing with ſome other Matter; and conſequently, thoſe Countries nearer the Poles, whereto they are driven by the Sun's Heat, muſt abound with them, more or leſs, in proportion to the Ability or

Inabitlity of the Sun's Rays to drive them again from thence: and theſe extremely minute and active Particles, being continually in Motion, ſtrike into, penetrate, and fix between the Pores of all Bodies capable of receiving them. Thus, mixing with ſaline Exſudations from, or certain Salts contained in Earths, Stones, *&c.* they may probably incorporate therewith, and concrete into the hexagonal Shoots of Cryſtal: filling up the Interſtices of Water, and becoming therewith embodied, they compoſe that hard Subſtance we call Ice †; which differs nothing from Cryſtal in Clearneſs, and perhaps would have the like Form, did not the Quantity and Situation of the Fluid prevent it; ſince we find that Water, falling in ſmall Drops, is concreted with the ſame Particles into an hexangular Figure.

Theſe Particles ſtriking into the Bodies of living Animals occaſion the Senſation of Cold: if their Quantity be great, they produce firſt a ſevere Pain, and then a Numbneſs, by impeding the Circulation of the Animal Fluids; and if they are not driven away by Heat from Motion or otherwiſe, or their Quantity be much increaſed, they ſtop the Circulations intirely, and bring on certain Death:

† The freezing or ſudden Change of Water into Ice, gives the beſt Idea, how Cryſtal, Gems, &c. may be form'd, and that too perhaps in a very ſudden Manner.

Death: and animal dead Bodies frozen become as hard as Stone. Hence it appears, that freezing is not the Reſult merely of the Abſence of Heat, but is really owing to ſome active and penetrating material Principles, which by mixing with other Bodies become thereby fixt: and the Exiſtence of ſuch Principles in the Air is farther apparent from the ruſting of Metals, the Eroſion of Stone, Glaſs, *&c.*

The Suppoſition that *Salt-Petre* is compounded in great meaſure of this ſame volatile acid Spirit exiſting in the Air, is ſtrengthened, not only by the manner of its Production, but alſo from its ſtriking the Tongue, when taſted, with a pungent Senſation of Cold, like what this ſame Spirit in the Air gives: Moreover, a volatile acid Spirit may be obtained from it in conſiderable Quantity, whoſe Particles are ſo active and powerful, that they penetrate, disjoin, and ſeparate the component Particles of all Metals except Gold, as well as Stones and moſt other Bodies.

Suppoſing ſuch Spirit one of the chief Principles of *Salt-Petre*, may not its exceeding Volatility, when ſuddenly and violently excited to Action, by the Fire contained in Sulphur kindled by Charcoal, produce all the prodigious Effects of Gunpowder *? and

* Vid. *Queries*, p. 26.

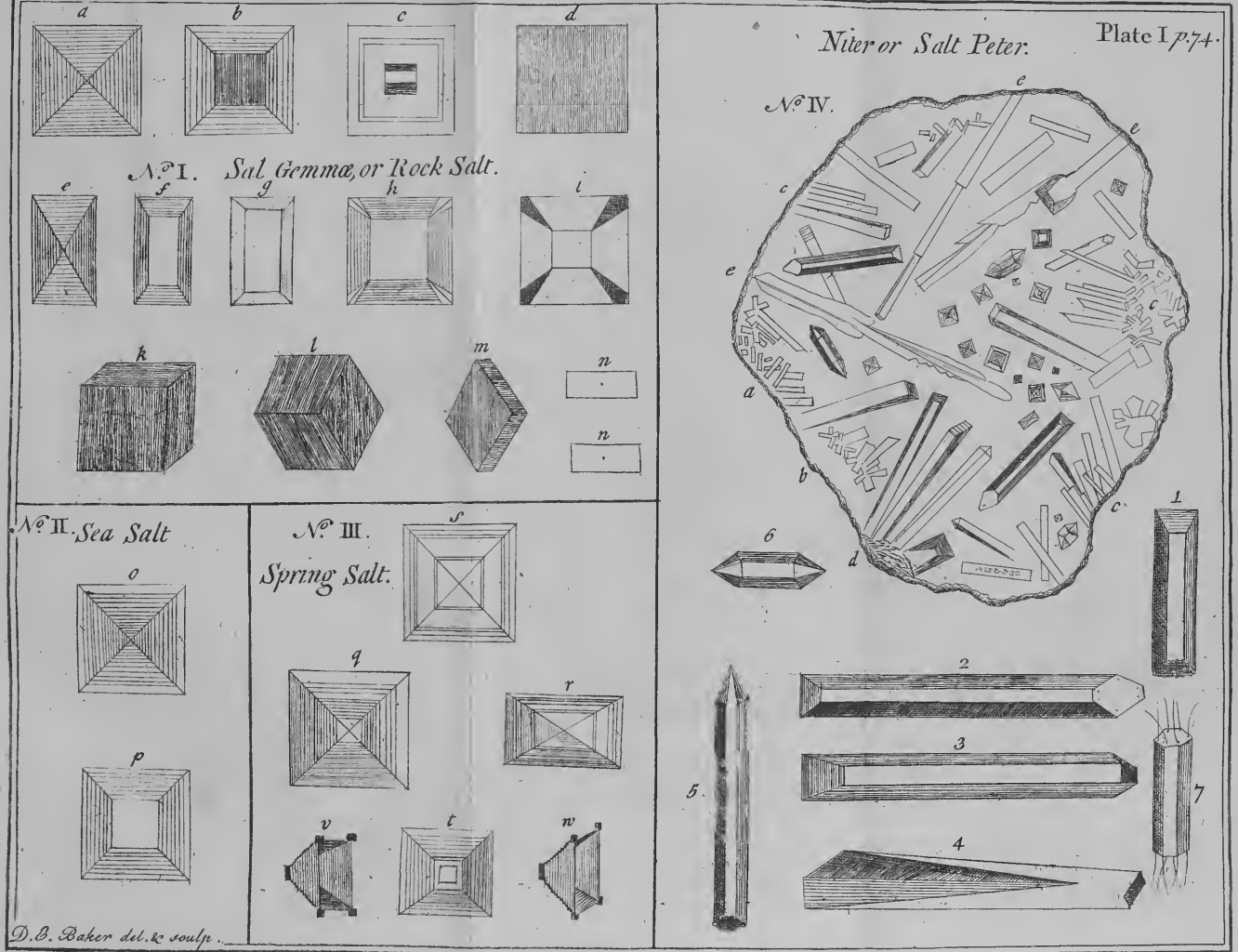
and alſo by certain Mixtures in the Air, become the Cauſe of Thunder, Lightning, and other wonderful Phænomena?

The foregoing Conjectures, into which I fear I have been led too far by my Subject, may 'tis hoped be forgiven, as they are ſubmitted intirely to the Conſideration of better Judges, without the leaſt Deſign of impoſing them on any one.—But to return to the known Properties of *Salt-Petre*.

It is ſaid to be the only Diſſolvent of Silver, as Sea-Salt is of Gold: for Silver is diſſolveable in no Menſtruum yet known, unleſs there be Nitre in it; and yet if Salt be added thereto, the Mixture will no longer diſſolve Silver but Gold. It preſerves the Fleſh of Animals from Putrefaction as well as Sea-Salt, and has the ſingular Property of giving it a red Colour*. In Diſtillation alſo, the Fumes that ariſe from Nitre are red.

CHAP.

* The Roots of Madder mixed with the Food of Animals tinges their Bones of a curious Red. Vid. *Philoſoph. Tranſ.* N° 442, and 443, where Experiements in Proof thereof, are given by Mr. *Belcher*, F.R.S. The ſame is likewiſe confirmed N° 457, by farther Experiments made by Monſ. *Du Hamel du Monceau*.


Nitre or Salt Peter.
Plate I p.74.
N.o IV.
N.o I. Sal Gemmæ, or Rock Salt.
N.o II. Sea Salt
N.o III.
Spring Salt.
D.B. Baker del.& sculp.

CHAP. X.

Of VITRIOL *in general.*

THE moſt celebrated of our modern Chemiſts ſuppoſe an acid Spirit exiſting univerſally in the Air, and pervading the whole terraqueous Globe. This, they tell us, is an uniform Matter, or firſt Principle, diſtributed every where throughout the Earth and Atmoſphere; though of a Nature ſo extremely ſubtile, that it never becomes ſenſible, unleſs compounded with other Subſtances; but incorporating readily with different Kinds of Matter, it compoſes, they ſay, therewith all the Variety of Salts, Cryſtals, Gems, Metals, and Minerals; the Colour, Figure, Solidity, and other Properties whereof are owing to the Difference of ſuch Admixture.

This is ſometimes called * the *Sal Acidum Foſſile*, at other times the *Vague Acid*. Compounded with Earth, and an oily Matter, it is thought to be the Baſis of *Sulphur*; of *Alum* with a cretaceous, and of *Vitriol* with a metalline Subſtance. It is alſo ſuppoſed to be the ſaline Part or Principle of all Salts, which Monſ. *Homberg* reduces to three Kinds only, *viz. Nitre*, *Sea-Salt*, and *Vitriol*.

The

* Vid. *Woodward*'s *Method of Foſſils*, p. 37.

The Configurations and Cryſtals of Vitriol vary according to its different Kinds: and its Difference in Kind is ſuppoſed owing to different Admixtures of the ſame, or different metallic Matter, with that acid Salt (or Spirit) which is the Baſis of all kinds of Vitriol. Thus, when Copper is diſſolved by and incorporated therewith, the Vitriol produced is blue; when Iron is the Metal, the Vitriol is green; and Lead, Tin, or *Lapis Calaminaris* mixed with Iron is imagined to render the Vitriol white. There is ſtill farther Variety; but Iron appears to be a conſtant and principal Ingredient in the green and white, as Copper is in the blue.

What occur'd in the Examination of each comes next to be deſcribed.

CHAP. XI.

Blue VITRIOL.

ALL Vitriol of this Colour is ſuppoſed to receive its Teint from Copper; the beſt is produced in *Hungary* and the Iſland of *Cyprus*.

A Drop of the Solution heated a little, and examined as before mentioned, produces Cryſtals round the Edges, very ſhort at

at the Beginning, but increaſing gradually as repreſented *Plate* II. (in the Drawing called *Blue Vitriol)* at the Figures 1, 2, 3, which denote their Difference of Form, and the Progreſs of their Growth. Theſe cryſtaline Shoots are ſolid, tranſparent, and regular, and reflect the Light very beautifully from their poliſhed Sides and Angles. As the watery Part evaporates, numbers of long ſlender Bodies reſembling Hairs are ſeen here and there, ſome lying Side by Side, as it were in little Bundles (vid. 4.) and others croſſing one another, in ſuch manner as to ſeem all radiating from a Center, and compoſing ſtar-like Figures, which ſee at 5, 5. This Salt proceeds but ſlowly, and requires ſome Patience before the Configurations begin to ſhoot: which they do at laſt, and that towards the Middle of the Drop moſt commonly, after a very pretty Faſhion, as at 6; and it is to be obſerved, that here alſo the principal Lines iſſue from a Center. Any farther Deſcription of the Drawing ſeems unneceſſary: but it is remarkable, that none of the regular Cryſtals are found in this Way of Examination, though they are to be obtained in good Plenty by the uſual Method of Evaporation, *&c.*

One of theſe regular Cryſtals, of the Size they are commonly found in the Shops, is repreſented by the two Figures A and B, which

which ſhew exactly the different Sides thereof. It conſiſts of ten Planes.

If a Piece of Iron be left for ſome ſhort time in a Solution of blue Vitriol, its Surface will appear of a Copper Colour, and is really covered with Particles of Copper, either precipitated upon, or attracted by the Iron, to which they firmly adhere, and whoſe Pores they ſeem to fill. This may ſerve to ſhew, after what manner ſome Springs of Water are able to perform what is uſually called a Tranſmutation of Iron into Copper; which indeed is nothing more than a gradual Diſſolution of the Iron, whoſe Place becomes as gradually ſupplyed, and its Figure aſſumed by the minute Particles of Copper floating in the ſaid Water: ſo that, although a Maſs of Copper may be found, after a Length of Time, inſtead of a Maſs of Iron, there is no Tranſmutation in the Caſe. The whole Fact ſeems only to imply, that the minute Particles of Copper wherewith the Water is ſtored, being much ſmaller than the Pores or Interſtices between the Particles of Iron, do firſt of all get into and fill up the ſaid Interſtices. We have then a Maſs compounded of Iron and Copper; but the Iron Parts thereof becoming gradually corroded and waſhed away by the Water (the mineral acid Salts it contains rendering it a Menſtruum thereto) their Places are immediately occupied by

by Particles of Copper, which the Water brings along with it continually; and a Body of Copper at length is ſubſtituted in the room of the Iron that was corroded and waſhed away. The Petrifaction of all Bodies that were originally of ſome other Subſtance than what they now appear to be, was probably produced after a like Manner; for it ſeems highly improbable that any Subſtance whatever can ſtrictly ſpeaking be converted into a Subſtance of ſome other Kind, however Appearaces may happen to impoſe upon us.

Dr. *Brown* informs us in his Travels, of two vitriolic Springs, called the old and the new *Ziment*, riſing from a Copper Mine in *Hungary*, which in fourteen Days turn Iron left in their Waters into Copper, and that too more pure, ductile, and malleable, than any Copper extracted from the Ore: that he took out with his own Hands from one of theſe Springs the Figure of an Heart, which had been put thereinto eleven or twelve Days before, and found it as perfect Copper as it had been Iron when put in. Some, he adds, will not allow this to be a Tranſmutation, but argue, That the Waters being ſaturated with a Vitriol of Copper, and finding a Body ſo eaſy to receive it as Iron is, it inſinuateth thereinto ſo far as to divide and precipitate the Iron, leaving

leaving its own Subſtance inſtead thereof *. And this moſt certainly is the Fact, though the Doctor ſeems to doubt it; the Purity of the Copper may be brought in Proof, and is not to be wondered at, for the minute Particles thereof, that floated in the Water, and were depoſited in the Pores of the Iron, muſt neceſſarily be leſs blended with foreign Matter than any Copper in its Ore can be.

There are Copper Mines in the County of *Wicklow* in *Ireland*, called the Mines of *Crone Bawm*, or *Corona Alba*, on the North Side of the River *Arklow*, where the Water raiſed from the Mines, that uſed to run away in Waſte, has lately been converted to great Profit: for by placing Iron Bars on Beams of Timber fixed for that purpoſe acroſs large Pits or Ciſterns, (floored with ſmeoth Flags and lined on the Sides with Stone and Lime) through which the Water runs, the Iron becomes incruſted in a few Days with Particles of Copper: which, being ſwept off from Time to Time, and falling to the Bottom, are, when a Quantity is collected, taken thence, in a fine brown Powder conſiſting of Copper and the Ruſt of Iron; which affords, when ſmelted

* Vid. *Brown*'s Travels, 4to, *p.* 109.

ſmelted and purified, a rich Copper, 10 £ per Ton more valuable than what is obtained from the Ore of the ſame Mine.—— This was diſcovered, by obſerving, that ſome Iron Tools of the Workmen, which had fallen accidentally into the Water, were after a while incruſted with Copper.

A Chain of theſe Pits is already made, each 10 Feet in Length, 4 in Width, and 8 in Depth: and as many more may be ſunk as People pleaſe, there being a continual Supply of Water to run through them all. They make uſe of ſoft Iron, which attracts the Copper Particles beſt, diſſolves, mixes, and participates with them in form of a brown Duſt. A Ton of Iron in Bars produces one Ton, nineteen Hundred, and two Quarters of brown Duſt; and each Ton of Duſt ſmelted, affords 16 Hundred Weight of pure Copper. There are at preſent about 500 Tons of Iron in the Pits. A large Bar of ſoft Iron will be diſſolved in about 12 Months *.

N. B. Whilſt the minute and inviſible Particles of Copper are floating at Liberty

* The above Account is the Subſtance of a Letter to Sir *Hans Sloane*, which he favoured me with the Uſe of; and alſo of another Letter communicated to the *Royal Society* by Lord *Cadogan*: both theſe Letters were written by the Reverend Mr. *William Henry*, who was himſelf upon the Spot. I have alſo a Lump of Metal, wherein moſt of the Iron has been diſſolved in the Water, and its place ſupplied by Particles of Copper.

in any Menſtruum, they are ſtrongly attracted by Iron; inſomuch that if a Needle or the Point of a Knife be held but for a few Minutes in a Solution of blue Vitriol, or if blue Vitriol be wetted and rubbed upon Iron, it will preſently be caſed over with Copper: and yet when theſe ſame Particles are collected into a Maſs of Copper, there ſeems no Attraction between that Maſs and a Maſs of Iron, nor has the Magnet any ſenſible Effect on Copper.

Copper affords a blue or a green Tincture, according to the Menſtruum wherein it is diſſolved; and therefore is ſuppoſed to ſupply Colour to the *Emerald*, *Sapphire*, *Turquoiſe*, *Lapis Lazuli*, *Lapis Armenus*, and moſt other Stones and Minerals that are either green or blue, as well as to the Subject we are at preſent treating of. The amazing Variety of *Blues* and *Greens* deducible from this Metal, and the Changes of one into the other, are exceedingly worth the while of every curious Perſon to ſatisfy himſelf about by a Train of eaſy Experiments; the Way of making which may be found in *Boyle*'s Treatiſe of Colours, in *Boerhaave*'s Chemiſtry, as tranſlated by Dr. *Shaw*, Vol. II. page 342, *&c.* and in *Hill*'s Letter, printed at the End of his *Theophraſtus*, on *the Effects of different Menſtruums on Copper*; where we are informed, that,

that, of the Mineral Acids, Spirit of Sea-Salt, Spirit of Nitre, and Aqua Regia, produce with this Metal different Kinds of *Green:* Oyl of Vitriol, Oyl of Sulphur, and Aqua Fortis, different Degrees of *Blue:* that, amongſt the vegetable Acids, diſtilled Vinegar, Juice of Lemon, and Spirit of Verdigreaſe (which is a Vinegar abſorbed by Copper) afford different *Greens:* that, of the fix'd Alkalies, the Salt of Wormwood, Pot Aſhes, and Oyl of Tartar per deliquium, give all a deep and delightful *Blue*; as do alſo, among the volatile Alkalies, Spirit of Sal Armoniac, Spirit of Urine, and Spirit of Hartſhorn: that, of the neutral Salts, crude Sal Armoniac produces a fine *Blue*; native Borax a *deep*, and Sea-Salt a *Whitiſh Green*.

" A Solution of Copper in any of the " beforementioned Acids, ſo weak as " to leave the Menſtruum colourleſs like " Water, may in an Inſtant, by the Af- " fuſion of a few Drops of Oyl of Tar- " tar per deliquium, be converted into a " glorious *Blue*; or by a like Quantity of " Spirit of Nitre, into a beautiful *Green:* " nay, by this means made *Blue*, may be " yet changed into *Green* by a larger Quan- " tity of the Acid: and even when thus " made *Green*, again converted into its for- " mer *Blue*, by a yet larger Quantity of " the Alkali.

" The blue Tinctures of Copper made " in the fix'd Alkalies, may alſo be di-

" vested of their Colour, and rendered co-
" lourless and pellucid like Water, by Acids,
" if the Proportions be carefully regarded.
" The blue Liquor here is made *colourless*,
" as the colourless Liquor was before made
" *Blue*; and the pellucid Liquor thus pro-
" duced, will exhibit all the Phænomena
" before described in that originally colour-
" less. To this it may be added, that even
" the strong blue and green Solutions are ea-
" sily changed from Blue to Green, and from
" Green to Blue in the same Manner." *

And how far Copper can diffuse its Tincture, (or its Parts become divisible) may be learned from Mr. *Boyle*, who found a single Grain of Copper dissolved in Spirit of Sal Ammoniac, would make 256806 times its own Bulk of clear Water of a blue Colour; would give a manifest Tincture to above 385200, and a faint yet distinguishable one, to more than 530620 times its own Bulk ‡.

CHAP. XII.

Green VITRIOL, or *English Copperas.*

OUR Green Vitriol contains a great deal of Iron, but appears not to hold any Copper, which makes its Colour difficult

* *Hill's Theophrastus*, pag. 188, 189.
‡ Vid. *Boyle* Abridged, Vol. I. pag. 408.

ficult to account for: ſince all mineral Subſtances, whoſe Colour is blue or green, have been generally ſuppoſed to derive their Colour from Copper.

When diſſolved in Water, it conſtantly drops to the Bottom a yellow ferrugineous Sediment; which being taken away, the remaining Liquor, after a due Time of Reſt, affords Cryſtals much clearer and of a finer Green than the Vitriol was at firſt. Theſe being diſſolved again throw down another yellowiſh Sediment, but in much leſs Quantity than before, and when cryſtalized a-new appear of a ſtill more lively Colour. And by repeating this Operation, they may be rendered perfectly tranſparent and of a delightful Green; tho' after all ſome Iron will ſtill be left, which ſubjects them to contract a Ruſt, if expoſed to the open Air.

A Drop of the Solution, moderately heated, and applyed to the Microſcope, begins to cryſtalize about the Edges, and proceeds gradually, as the Figures 1, 2, 3. *Plate* II. N° 2. repreſent, under the Name of *Green Vitriol*. After waiting ſome Time, the Configurations puſh out, ſuddenly and haſtily, towards the Middle, in the Manner repreſented by Figure 4, which begins at *a*, and thruſts forwards and ſideways at the ſame Inſtant, with wonderful Order and Regularity, to the other Extremity *b*,

where the whole Proceſs is at an End. Its regular Cryſtals are rarely found in this Examination, but a Couple of them as obtained by diſſolving a Lump of our Subject in boiling Water, and leaving it at Reſt for a Day or two, are placed at the Side of the Drop. The firſt of them A, is one out of a great many that were formed on the Side of the Glaſs wherein the Solution ſtood, and adhered thereto. Theſe being produced in the clear Part of the Liquor, above the ferrugineous thick Sediment which had been precipitated but was not taken away, were much greener and more tranſparent than the Vitriol firſt diſſolved. Excepting ſome Irregularities they were all of the ſame Shape, with Sides nearly correſponding.

The Figure B repreſents an Octaëdron, that being the general Shape of many Cryſtals formed in the yellow thick Sediment at the Bottom, a Fortnight or three Weeks after, the clearer Part of the Liquor having been poured away: and conſequently the Difference of Figure between this and the former muſt be imputed to the much greater Proportion of Iron in this than that.

Our green Vitriol, or Engliſh Copperas, is made from the *Pyritæ*, that are found in great abundance on the Shores of *Suſſex*, *Eſſex*, *Kent*, &c. Theſe Bodies are

of

of a ponderous and compact Subſtance, contain Metal and Sulphur, have a ruſty ferrugineous Outſide, but internally appear, when broken, ſometimes of the colour of Braſs, Silvery ſometimes, and ſometimes like Iron; the Matter compoſing them is diſpoſed in Striæ, or a linear Direction diverging from a central Point to the Circumference, if the Stones have any thing of a circular or cylindric Figure; or lying parallel and perpendicular to the flat Sides, if their Form be flattiſh. After being long expoſed in Heaps to the Air and Rain, the Salts begin to act, vitriolic Efflorescencies puſh out upon the Surface, they become brittle, fall to pieces, and diſſolve into a Liquor. This Liquor when boiled two or three Days in a leaden Cauldron, (Pieces of Iron being thrown in from Time to Time during the boiling and diſſolving in the ſaid Liquor) is diſpoſed afterwards in convenient Veſſels, where it ſtands for about a Fortnight to cryſtalize into Vitriol. A great Work of this Kind is, or was not long ago, carried on at *Deptford*.

CHAP. XIII.

White VITRIOL.

THE White Vitriol from *Goſlar* in *Germany*, as well as that from *Hungary*, contains ſome little Copper, but the common Sort with us has no other Metal in it beſides Iron, unleſs, as ſome ſuppoſe, there is alſo a ſmall Quantity of Lead or Tin. The Iron contained in the *Green* and *White*, as well as the Copper in the *Blue*, is not in any conſtant Proportion, but frequently more or leſs in different Pieces of the ſame Parcel, which occaſions ſome Varity in Experiments made therewith.

A Drop of the Solution of white Vitriol begins to ſhoot at the Edges, by a gentle Degree of Heat, either in ſmall angular Figures, or minute curvilinear Spiculæ, both which are repreſented in *Plate* II. at 1, 1. The former of theſe ſpreading conſiderably in Breadth, and protruding very ſlowly forwards, produce thoſe lineated Figures ſhewn at 2 on one Side of the Drop, which are formed by two Planes inclining to one another in an Angle of about 120 Degrees: the latter, *viz.* the *Spiculæ*, ſpreading likewiſe and flattening at the Ends, ſhew themſelves nearly as repreſented by 2 on the contrary Side.

Some of them however ſhoot farther into the Drop, in the Manner ſhewn at 3, 4, and 5: and many ſo ſhot out have other ſmaller ones protruded from their Sides, parallel to one another, and forming an Angle with their main Stem of about 60 Degrees, as at *a, a:* when the Proceſs is nearly over, many extremely minute *Spiculæ* ariſe in the Interſpaces; ſome uniting in, or rather ſhooting from Centers, and making a very pretty † radiated Appearance, like what was before obſerved in the Blue Vitriol; whilſt others of the ſame *Spiculæ* are ſeen ſcattered and diſperſed about the Drop in all Directions, as at 8. Theſe *Spiculæ* may be termed a Characteriſtic of the Vitriols, being uſually found in all of them, when examined by the Microſcope with Care; but as ſometimes the *Green* is ſeen without them, I have taken no Notice of them there.

The Figure ſhewn at 6 is ſeldom to be met with, but when the Fluid Part of the Drop is ſuffered to evaporate without any Heat; and it ſeems nearly to approach the regular Cryſtals, which are next to be deſcribed.

As a Solution of our preſent Subject does not ſo eaſily cryſtalize by the common Methods,

† It is obſervable, that many of the *Pyritæ* exhibit Lines diverging from a Center, exactly in the ſame manner.

Methods, after trying ſeveral times to make it do ſo without Succeſs, I have contented myſelf with examining the * *Gilla* or *Sal Vitrioli* made by the Chemiſts: two Figures whereof A B as magnified above a thouſand times in the Area, are given at the Side of the Drop. They appear to be quadrilateral Columns, the Inclination of whoſe Sides is oblique, having generally a quadrilateral Pyramid at each End, formed of triangular Sides correſponding to thoſe of the Column, as at A; but ſometimes theſe triangular Planes interſect, in ſuch a manner that the Angle at the Apex is comprehended under only three of them, as at B.

Vitriol in conſiderable abundance is found in Subſtance and of different Colours, blue, green, white, and red, in ſeveral Parts of *Hungary*, *Germany*, and other Countries: but very little, if any, native Vitriol is ever found in Maſſes or Lumps in *England*; all produced here being obtained by Art from the *Pyritæ*, and of the white the greateſt Part comes to us from abroad. The Appearance of ſuch White Vitriol is extremely like Loaf Sugar, it has a ſweetiſh diſagreeable ſtiptic Taſte, and when diſſolved

* Theſe Salts or Cryſtals are obtained by the Help of Spirit of Vitriol, or, as *Lemery* directs, by diſſolving White Vitriol in the Phlegm of Vitriol.

diſſolved in Water, throws to the Bottom a ferrugineous Sediment like the Green.

It would be endleſs to enumerate all the Uſes of Vitriol. Sir *Kenelme Digby*'s ſympathetic Powder, ſo famous in its Day for the Cure of Wounds, was nothing elſe but Vitriol expoſed to the Summer's Sun for ſeveral Days and powdered. But amongſt all the reſt, its being an Ingredient abſolutely neceſſary for the making of Ink is not the leaſt to be regarded. Any Vitriol that contains Iron will ſerve to this Purpoſe, of what Colour ſoever it be: the Green however is commonly preferred, as holding a greater Quantity of that Metal: but the White ſometimes is not leſs ſtocked with it, and then will do full as well. Galls unripe, or gathered when they are of a blueiſh Colour, before they come to their full Growth, being beaten to Powder, and infuſed in Water, give the Water a ſtiptic Taſte, without altering its Colour much; but a proportionable Quantity of powdered Vitriol, or a Solution of Vitriol being mixed therewith, turns it inſtantly as black as Ink, and wants only a little Gum to make it Ink indeed. A Decoction of the dryed Leaves of red Roſes, of Sage, Oak Leaves, or the Rinds of Pomegranates, produces the ſame Appearance therewith. It alſo in like manner blackens an Infuſion of Green Tea; and

and therefore a few Tea Leaves put to ſteep for ſome Minutes in any Mineral Water made hot, will readily diſcover if it contains Vitriol, by ſuch its Change of Colour: the Proportion of the Vitriol may likewiſe be gueſſed at by the Deepneſs or Paleneſs of the Tincture.

On writing with a Solution of Green Vitriol, nothing is ſeen upon the Paper when dry: but by rubbing it over with a Decoction of Galls, what was written becomes black and legible. Spirit of Vitriol wiped gently upon this, makes it vaniſh again immediately: Oyl of Tartar *per deliquium* reſtores the Letters once more, though not black but yellowiſh †.

A ſtrong Decoction of red Roſes mixed with a Solution of Vitroil produces a black Ink, which on dropping Spirit of Nitre into it becomes inſtantly red, and is farther convertible into a greyiſh Liquor, by adding a little of the volatile Spirit of Sal Armoniac.

Good Writing Ink being not always or every where to be procured, it will not perhaps be unacceptable to give here an eaſy Way of making it, which I can recommend from many Years Experience.

To one Quart of Rain Water, or ſoft River Water, put four Ounces of blue Galls

† Vid. *Lemery*'s Chemiſtry, chap. 18.

Galls bruiſed, two Ounces of green Vitriol or Copperas, and two Ounces of Gum Arabic groſly powdered. Let the Mixture be well ſhaken or ſtir'd about now and then, and in twenty-four Hours it will be fit for Uſe. It is moſt conveniently made in a wide-mouthed Bottle that will hold near double the Quantity, where it may ſometimes be ſhaken together briſkly; but be ſure you let it ſettle again before you pour any off. When you have uſed all that can be got off clear, a little more than half the Quantity of the ſame Ingredients will make you another Quart.

What is written with this Ink looks pale at firſt, but after a few hours becomes of a fine black, and I believe will never change.

CHAP. XIV.

Diſtilled VERDIGREASE.

VERDIGREASE is a blueiſh green Efflorescence * or Ruſt, produced on Plates of Copper, by corroding the Surface thereof with that penetrating acid Spirit which the Huſks of Grapes abound with after they have been preſs'd and laid together to ferment. This Ruſt being

* Vid. *Lemery*'s Chemiſtry, chap. vi. *Boerhaave*'s Chemiſtry, by *Shaw*, Vol. II. pag. 137.

being digeſted with diſtilled Vinegar in a conſiderable Degree of Heat, and diſſolving partly therein, affords a Liquor of a moſt beautiful green Colour, which after Evaporation, being ſet in a cold Place, produces tranſparent and elegant green Cryſtals, that are called uſually by the Name of *Diſtilled Verdigreaſe*, but are really a Vitriol loaded with the pureſt Particles of the Copper.

If theſe Cryſtals are diſſolved in warm Water, and a Drop of it be apply'd to the Microſcope immediately, it uſually produces abundance of the regular Figures 1, 2, 3, 4, 5, 6, 7, (exhibited at the Side of the fourth Drawing, *Plate* II.) without forming any conſiderable Configuration: but if the Solution is ſuffered to ſtand quiet for a few Hours, and a Drop of it be heated over the Fire on a Slip of Glaſs, till it begins to concrete about the Sides, and then examin'd, ſharp-pointed ſolid Figures (biſected by a Line through the Middle, from which they are cut away towards the Edges) will be ſeen, ſhooting forwards, as repreſented 1, 1, 1: which Figures are oftentimes ſtriated very prettily from the middle Line to the Edges, obliquely, as 2, 2, may ſerve to ſhew. They both ariſe frequently in Cluſters, and ſhooting from a Center as at 3, 3.

The forementioned Figures are a long while growing; and whilſt they are doing

ſo,

ſo, ſeveral regular Cryſtals appear forming in different Parts of the Drop, of the moſt lovely Emerald Colour, and reflecting the Light from their Sides and Angles, which are as exactly diſpoſed and finely poliſhed as if they had been cut by the moſt ſkilful Jeweller. Theſe Cryſtals are ſhewn in the Drop at 4, 4, but much better, becauſe magnified a great deal more, at the Side of it, by the Figures 1, 2, 3, 4, 5, 6, 7.

No Configurations form themſelves in the Middle of the Drop till the Fluid be nearly evaporated, but when they begin to form they proceed ſomewhat haſtily, and therefore muſt be attended cloſely. Their common Figure reſembles two long *ſſ*, croſſing each other in an Angle of about ſixty Degrees, and ſhooting Branches every Way: each of which again protrudes other Branches from one, and ſometimes both its Sides, making together an Appearance like four Leaves of Fern conjoyned by their Stalks, as at 5, 5. Separate Cluſters of the ſame ſharp-pointed Figures, as thoſe at the Edges of the Drop, are formed alſo frequently in the Middle of it, as 6. Sometimes alſo they put on another Form like the Leaves of Dandelion, as at 7. Very beautiful Figures are likewiſe produced by a Kind of Combination of ſharp Points and Branches, in the Manner repreſented 8 8.

All

All the beforementioned appear of a moſt lovely green Colour, but deeper or paler according to the Time of their Production; the firſt produced being conſtantly the deepeſt. Towards the End of the Proceſs ſome circular Figures are formed, extremely thin, and ſo ſlightly ting'd with green that they are almoſt colourleſs, but with Lines radiating from a Center to the Circumference, like the ſtar-like Figures of *Alum* hereafter to be deſcribed. Theſe are ſhewn 9, 9. When all ſeems in a manner over, Bundles of Hair-like Bodies appear frequently, ſcattered here and there throughout the Drop, in the ſame Manner as deſcribed in the blue and white Vitriols.

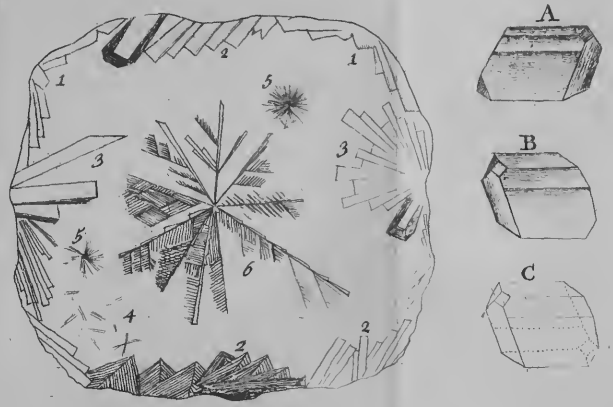
CHAP. XV.

ALUM.

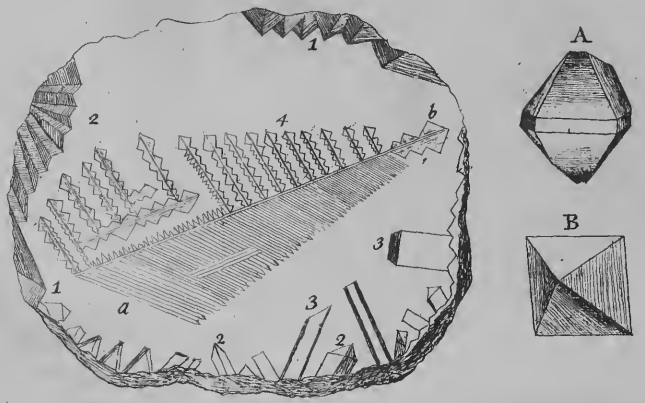
THE Configurations of this Salt abound with Beauty and Variety, and prove more or leſs perfect according to the Strength of the Solution, and the Degree of Heat employed in making the Experiment, to judge of which a little Experience will be found needful.

The Solution, however ſated with *Alum*, will not be found over-ſtrong after ſtanding ſome

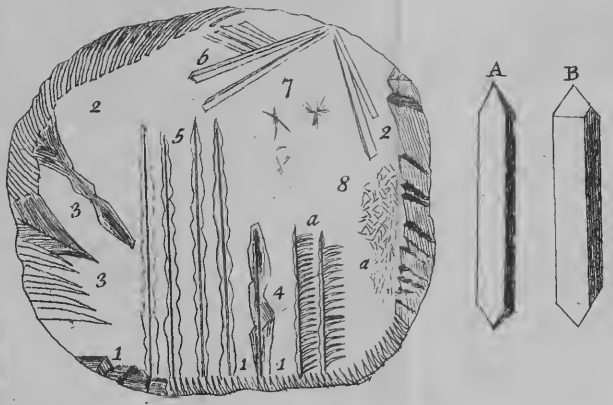
Blew Vitriol.



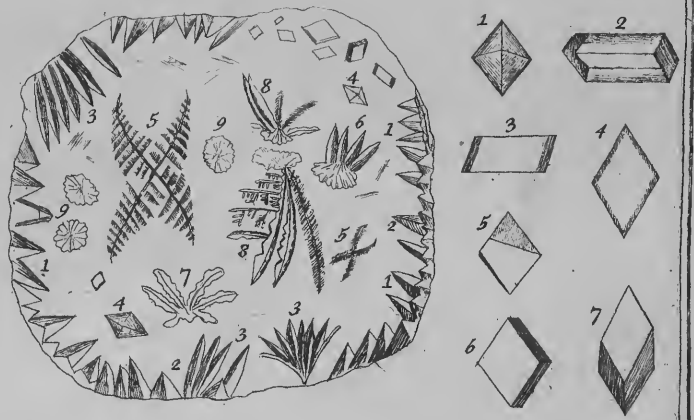
Green Vitriol.



White Vitriol.



Verdigreafe diftilled.



D.C. Baker del. & sculp.

ſome Days, for in that Time it will have precipitated many Cryſtals to the Bottom, whereby the Liquor is ſometimes left too weak for our Purpoſe; but then by holding the Phial over or near a Fire, the Cryſtals will again diſſolve, and be taken up a-new into the Fluid. 'Tis not however adviſeable to make uſe of it as ſoon as this is done, unleſs we want to produce nothing elſe but Cryſtals: for if, after this, it be employed before it has had a little Time to cool and ſettle, it is very apt to form into Cryſtals only: but when it has ſtood about half an Hour, a Drop placed on a Slip of Glaſs and heated properly, exhibits commonly at the beginning a dark Cloud, which appears in Motion ſomewhere near the Edge, and runs pretty ſwiftly both to the Left and Right, until it is either ſtopped by the Intervention of ſome regular Cryſtals, or elſe proceeds onwards both Ways at once, and nearly of the ſame Height, till having ſurrounded the whole Drop the two Ends ruſh together and joyn; the Progreſs towards which is attempted to be ſhewn, *Plate* III. N° I. *a a*.

This cloudy Part of the Drop that ſeems violently agitated whilſt it is running round, appears on a ſtrict Examination to conſiſt of Salts, ſhot into long and very ſlender Lines, much finer than the ſmalleſt Hair, which croſs one another at right Angles, and form

as they go along, from their internal Edges, Rows of ſolid Cryſtals compoſed of many oblique plain Sides *b b*, and which have all a Tendency towards the Figures of the regular Cryſtals to be deſcribed preſently.

But it happens frequently, that in ſome Parts of the Drop many minute and circular Figures are ſeen, riſing at ſome little Diſtances from the Edge, whilſt the above mentioned Operations are performing in other Places thereof; which minute Figures enlarging themſelves continually, appear at laſt of a ſtar-like Form, or with Lines radiating and diverging from a Center, in the Manner repreſented *c c*.

After the Buſineſs is over about the Edges, a good deal of Patience will be requiſite to wait for the Configurations in the Middle of the Drop, which ſeldom begin till the Fluid ſeems almoſt wholly evaporated; when on a ſudden many ſtrait Lines appear puſhing forwards, whoſe Sides or Edges are jagged, and from which other ſimilar ſtrait and jagged Lines ſhoot out at right Angles with the firſt; theſe again have other ſmall ones of the ſame Kind ſhooting likewiſe from themſelves, and compoſe all together a moſt beautiful and elegant Configuration, the Order of which is attempted to be ſhewn at D.

Each

Each of these Lines increasing in Breadth towards its End, appears somewhat club-headed, as *e e e*.

Sometimes instead of sending Branches from their Sides, many of these Lines rise parallel to each other, resembling a kind of Palisadoe, and having numberless minute tranverse Lines running between them, as at F.

But the most wonderful Part of all, tho' not produceable without an exact Degree of Heat and right Management, is the dark Ground-work shewn at G, which consists of an almost Infinity of parallel Lines, having others crossing them at right Angles, and producing a Variety scarce conceivable from Lines disposed in no other Manner: the Direction of the Lines (which are exquisitely strait and delicate) being so frequently and differently counter-changed, that one would think it the Result of long Study and Contrivance.

During the Time this Ground-work is forming, certain lucid Points present themselves to view (on one Side thereof most commonly) which Points grow larger continually, with Radiations from a Center, and become star-like Figures, in the Manner of those beforementioned. Several of them likewise shoot out long Tails, which give them the Appearance of Comets: and at the End of all, a dark Lineation in va-

rious Directions, darts frequently through, and occupies all or moſt of the Spaces between them, making thereby no ill Repreſentation, when viewed by Candle-Light, of a Night-Sky illuminated with ſhining Stars, and tailed Comets, and rendering the whole Scene extremely whimſical and pretty.

Nor do theſe Configurations break away, or diſſolve, ſoon after their being formed, as many others do; but may be preſerved on the Glaſs in good Perfection for Weeks or Months, if Care be taken neither to exclude the Air wholly from them, nor put them in a moiſt Place: for in either Caſe they will be ſoon deſtroyed.

Being deſirous to preſerve ſome exceeding fine Star and Comet-like Figures, I faſtened another Glaſs of its own Size upon the Slip where they were formed; having firſt placed thin Pieces of Cork between, to prevent the Glaſſes from touching, and after all ſtopped the Ends and Sides with Sealing Wax, thereby to keep out the Air, which I imagined would ſpoil them: but contrary to my Expectation, in two Days the Figures were all obliterated; whereas another Configuration, covered with a Slip of Glaſs to preſerve it from being touched, but whoſe Sides were open to the Air, continued in great Perfection at leaſt two Years, and then too was ſpoiled by Accident.

The

The same Thing likewise happens to *Saccharum Saturni*, *Ens Veneris*, *Salt of Amber*, and some other saline Substances, whose elegant Configurations may be long preserved between Slips of Glass kept asunder as above directed, provided the Air be not pent up with them, and that the Place you put them in be dry. I have at this Time several Configurations formed some Years ago; and it will save much Trouble, and be most agreeable to People not overstock'd with Patience, to have always as many kinds as one can thus ready, to shew such Friends whose Curiosity may not be sufficient to make them attend to the whole Process.

A great deal of Exactness and Nicety is requisite as to the Degree of Heat, to make one and the same Drop produce all the Configurations presented in the Plate; tho' you will certainly meet with several of them in every Drop you try, unless the Heat be too long continued, in which Case the Fluid becomes hardened by the Fire into a kind of transparent Gluten, which never shoots at all, is not easily dissolveable, or to be got off the Glass without some Pains. On the other hand, if the Heat be violent, though not long, it shoots too fast, with much Irregularity and Confusion.

The regular Cryſtals are often formed in the ſame Drop with the other Configurations, as at *f*. But if not, they may eaſily be produced, either by uſing a Solution made with hot Water, before it cools; or by placing a Drop of a well-ſaturated Solution when cold, on a Slip of Glaſs, and ſuffering the Fluid to evaporate without any Heat at all. Cryſtals will alſo be formed by Precipitation after the Solution has ſtood ſome Time.

After numberleſs Obſervations to determine the Cryſtals of *Alum*, I find amongſt them the following Variety.

Some are exactly regular Octaëdra, compoſed of eight equilateral Triangles, as the Figure A.

But as they lye moſt frequently on one of their triangular Baſes, they appear in the Manner ſhewn at B.

Others appear like the above with their ſolid Angles cut off, forming thereby a Figure of fourteen Sides, eight of which are Hexagons, and the other ſix Squares, as C.

The Figure D frequently preſents itſelf, and ſeems alſo compoſed of fourteen Planes (*viz.* 12 quadrilateral, and two hexagonal) the Planes underneath being ſuppoſed to correſpond in Number and Figure with thoſe that appear above.

E repre-

E repreſents an eight-ſided Figure, conſiſting of two triangular, two hexagonal, and four quadrilateral Planes, two whereof ſlope downwards from the upper hexangular Plane, and the other two upwards from the under one.

The Figure at F is compounded of eight Planes, the undermoſt whereof is a large equilateral Triangle, from each Side of which a ſloping quadrilateral Plane proceeds. Theſe Planes are Trapezoids, each of them having a Side in common with that of the Triangle, another ſhorter one parallel thereto, and two others ſloping one towards the other, and towards the Side of the Triangle, in a Direction of about twenty Degrees,

The Plane which lyes parallel to the Triangle (which Plane in the preſent Figure is next the Eye) is hexagonal, three of its Sides being made up of the ſhorter parallel Sides of the Trapezia: the other three (which are leſs than theſe, being cut down perpendicularly, ſo as to meet the Angles of the large Triangle) form three other ſmaller Triangles, each whereof has one Side in common with the Hexagon, and the other two with the neighbouring Trapezoids.

Our *Alum* is obtained from a blueiſh mineral Subſtance reſembling Slate, which after being calcined and ſteeped in Water

for a due Time, that Water when boiled ſufficiently in Pans of Lead (the Lees of Sea-Weed Aſhes called Kelp, and the Quantity of Urine being mixt therewith) produces Shoots of *Allum*, after ſtanding a few Days. But as ſuch Shoots are ſeldom clean enough at firſt for Sale, they commonly are waſhed with or diſſolved again in Water, freed from their Impurities, and ſet to concrete a-new.

Vaſt Quantities are made in *Yorkſhire* and *Lancaſhire*, moſt of the Hills between *Scarborough* and the River *Tees*, as well as thoſe near *Preſton*, abounding with this Mineral; the Salts of which being diſſolved and put in Action by the Moiſture of the Air, if thereto expoſed, without being calcin'd, the Mineral falls in Pieces, and yields a Liquor whereof Copperas or green Vitriol may be made †.

Alum may alſo be procured from certain Earths by pretty much the ſame Means. An Earth of this Kind now lies before me, which was brought from *Africa*, where a conſiderable Tract of Land is ſaid to be of the ſame

† At *Altſettle* in *Bohemia* are Mines of black *Schiſtus*, whence they make great Quantities of Alum and Vitriol; and from a *Gleba Pyritoſa* found in the ſame Mines, they obtain much Sulphur. I am obliged to Dr. *James Mounſey* for this Information; and for Speciments of both the Subſtances, which he collected upon the Spot and ſent me.

ſame Sort *. It taſtes exactly like *Alum*, and in the *South Sea* Year 1720, a Quantity was imported in Hopes of making it turn to good Account: but the Miſchiefs ſuffered from other Projects at that Time, diſcouraged People from embarking in this, and we have heard no more of it ſince; nor indeed as *Alum* can be made ſo cheap from Materials found at Home, does it ſeem worth while to ſend ſo far on the ſame Account.

Alum ſeems ſo nearly a-kin to Vitriol, that the Addition of Copper or Iron is only wanting to make it the ſame Thing; as may be proved by a Diſtillation of it into an acid Spirit with either of them, whereby it becomes good Vitriol. On the other hand, Vitriol when freed from its metallic Particles, becomes aluminous, and yields on Diſtillation a Spirit undiſtinguiſhable by the niceſt Scrutiny from that of *Alum*. ‡

CHAP.

* I have alſo an aluminous Earth brought from *Maryland*, and given me by Mr. *Brook*.

‡ Vid. *Phil. Tranſ.* N° 104. p. 67.

CHAP. XVI.

BORAX.

BORAX is a ſaline Subſtance, very difficult in Solution unleſs in boiling Water, and even then requiring, according to *Boerhaave*, twenty times its own Weight.

When a Drop is given to be examined by the Microſcope, if it be held too long over the Fire no Cryſtals will ſhoot, but it will harden upon the Slip into a tranſparent Matter much reſembling Glaſs. The beſt Way is to give it a briſk Heat for about one Second of Time, and then applying it, the Cryſtals will quickly be ſeen forming about its Edges, as in *Plate* III. N° II. where their Beginning and Progreſs are ſo repreſented as to need no farther Deſcription.

In the middle Parts of the Drop no Cryſtals at all ariſe, but there are ſeveral tranſparent circular Figures, that from mere Specks grow gradually bigger, till they reſemble ſmall Drops of Oyl floating upon the Surface of Water: theſe alſo are ſhewn in the Drawing.

This Salt is ſaid to be found in *India*, *Perſia*, and *Tartary*, and to be brought from thoſe Countries rough and foul,

in

in Lumps or Cryſtals, of a yellowiſh and ſometimes of a dirty green Colour: but we really know little thereof with Certainty. The *Venetians* made great Profit heretofore by purifying it for Sale *, but that Trade at preſent is chiefly carried on by the *Dutch*; though I am told the Secret is become known, and has lately been practiſed with good Succeſs in *England*. It ſerves the ſame Purpoſes of fuſing and ſoldering Gold and other Metals, as the *Chryſocolla* of the Ancients did, for which Reaſon it is frequently called by the ſame Name, though theirs was quite another kind of Subſtance, the Knowledge whereof is probably loſt to us. Its glaſſy Quality renders it uſeful in dying, to give a Gloſſineſs to Silks; and Dr. *Shaw* proves (in the twentieth of his *Chemical Lectures*, Experiment 3d.) that by means of this Salt a Kind of Glaſs may be made of an extraordinary Degree of Hardneſs; and imagines the Arts of Enamelling, and of imitating precious Stones, may be greatly improved thereby †.

When

* Vid. *Shaw*'s *Tranſlation of Boerhaave*'s *Chemiſtry*, Vol. I. p. 110, in the Notes.

† Rough *Borax* is called *Tincal*, or *Tincar*. *Geoffroy* ſays, a ſalt muddy greeniſh Water found in ſome Copper Mines, evaporated to a certain Degree, then kept for ſeveral Months in Pits, whoſe Sides and Bottoms are plaiſtered with the Mud of the ſame Mines mixt with Animal Fat, the Pits being alſo covered with the ſame Plaiſter, produces the Lumps or Cryſtals of *unrefined Borax*.

When refined and pure it is bought in large cryſtaline Shoots clean and white, about the Clearneſs and Hardneſs of Alum, wherewith it is ſometimes adulterated: to the Taſte it is almoſt inſipid, but ſomewhat ſmooth and oily, and the more ſo the leſs it has been purified, for in its foul State 'tis conſiderably fat and greaſy.

A regular Cryſtal of ſuch purified Borax as taken by the Microſcope, is ſhewn on the Side of the Drop at A.

Some Years ago my worthy Friend Mr. *Peter Colinſon*, F. R. S. favoured me with a Subſtance ſaid to be brought from *Perſia*, and called *Native Borax:* 'tis in ſmall irregular flattiſh Pieces of a greyiſh white Colour, wherein, if nicely examined, abundance of ſhining Particles may be diſcerned: it is light and porous, of a very brittle Conſiſtence, ſomewhat urinous, and more pungent in Taſte than the Kind before deſcribed. A Solution of this did not ſhoot at all into Cryſtals, but in many Examinations filled the whole Drop with figur'd Bodies like that at B; which from being barely viſible, enlarged pretty faſt, to a Size (when viewed by the fourth Magnifier) as big in Appearance as the Figure here exhibited.

Theſe quickly fall to Pieces, and become diſſolved by the Air.

CHAP.

CHAP. XVII.

Salt AMMONIAC, *or* ARMONIAC.

WHAT the Ancients called by this Name, is ſuppoſed to have been a Salt generated in the Earth or Sands, from the Urine and Dung of Camels, (made uſe of by the Multitudes of Pilgrims that reſorted to the Temple of *Jupiter Ammon*) which, being ſublimed by the Sun, produced this Kind of Salt; and the Diſuſe of that Cuſtom for many Ages, is imagined to be the Reaſon why none of it is now found. What we have at preſent is undoubtedly factitious, being made of Urine, Sea-Salt, and Soot. It is ſuppoſed to come from *Egypt* or *Syria*, in round Cakes near three Inches thick, and about half a Foot in Diameter: in Colour it is greyiſh on one Side, and appearing, for the moſt part, black, or rather ſooty on the other. When broke, the Inſide (if good) is white, tranſparent and cryſtaline, and in Appearance much like Camphire. We are told, that in thoſe Countries they collect a Soot from the burning of Camel's Dung, which they ſprinkle with a Solution of Salt made in Urine of the ſame Animal, and then ſublime in Glaſs Veſſels, till a Cake is thrown up to the Top of each, correſpondent to the Shape of the Glaſs, which they muſt

break

break in order to get it out. — All this may perhaps be true, but I am apt to think it is made much nearer home, and by more easy means.

Some of this Salt dissolved in Water, and a Drop thereof placed on a Slip of Glass, to be examined by the Microscope, will be found to shoot with a small Degree of Heat; which must be very carefully observed, for if more Heat than just enough be given to it, the Configurations will run into one another, and make the Whole appear in great Confusion.

It begins with shooting from the Edges great Numbers of sharp, but thick and broad *Spiculæ*, from whose Sides are protruded as they rise many others of the same Shape, but very short, parallel to each other, but perpendicular to their main Stem, as at 1. *Plate* III. N° III. These *Spiculæ* arrange themselves in all Directions, but for the most part obliquely to the Plane from whence they rise, and many are frequently seen parallel to one another: which Particulars the Figure endeavours to express at 1. 1.——As they continue to push forwards (which they do without increasing much in Breadth) some shoot from them the small *Spiculæ* only, as at 2. Others, after they are nearly come to their full Growth, divide into two Branches in a Manner different from all other Kinds of

of Salt I have ever ſeen, by the Splitting of the Stem, longitudinally, from the Top almoſt to the Edges of the Drop, but without any Shootings from the Inſide, as is repreſented at 3.——Other Branches, beſides the ſmall *Spiculæ* mentioned above, protrude longer ones of the ſame Form, from whence others alſo proceed: which others ſhoot alſo ſmaller ones from them, and ſo on to many Gradations, as at 4.

Before the Middle of the Drop begins to ſhoot, ſeveral exceedingly minute Bodies may be diſcerned at the Bottom of the Fluid. Theſe riſe to the Top in a little while, and as ſoon as their Form can be diſtinguiſhed, whilſt yet extremely ſmall, they plainly wear the ſame Shape exactly, which they afterwards appear in when grown much larger, as is ſhewn at 5.——Their Growth is very quick, and pretty equal for a Time, but at length ſome one Branch gets as it were the Maſtery, and ſhooting farther than the reſt, forms the Figure 6. The other Branches inlarge but little afterwards, all the Attraction ſeeming biaſſed to this alone, from which more Branches being protruded, and they again protruding others, the whole appears like Figure 8.

'Tis not uncommon to ſee in the Middle of the Drop ſome different Configurations, where inſtead of the ſtrait Stems deſcribed

above, there is formed a Kind of *Zigzags*, with *Spiculæ* like thoſe in the other Figures, as at 7.

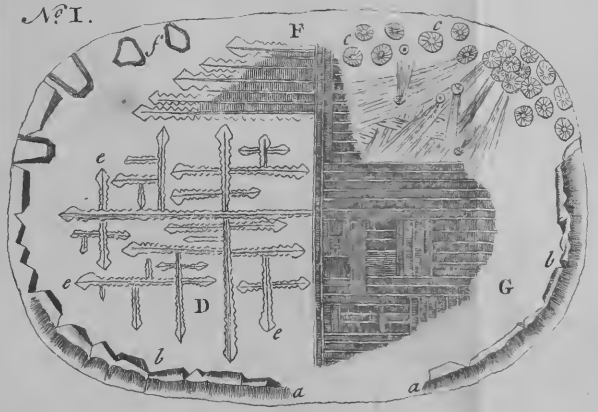
To obtain the Cryſtals of this Salt, 'tis neceſſary to place a Drop of a freſh Solution (made in warm Water) before the Microſcope, without giving it any other Heat than the Warmth of the Water. The regular Cryſtals will then appear as repreſented at the Side of the Drop A, B, C. The laſt of which Figures C is produced from the ſecond B, by new Formations at each Corner of the croſs Branches, when the whole Proceſs is nearly ended: but theſe Cryſtals are rarely ſeen unleſs the Solution be examined as ſoon as made.

Salt Ammoniac is particularly remarkable for rendering Water wherein it is diſſolved colder than any other Salt can do, and even equal in Degree to Water that is near freezing. Monſieur *Geoffroy* placed a common Thermometer of eighteen Inches long in a Phial wherein he had put a Pint of Water, and let it remain therein a ſufficient Time to adjuſt itſelf to the Temperature of the Water: he then put into the Water four Ounces of *Salt Ammoniac*, and in leſs than a Quarter of an Hour the Liquor in the Thermometer deſcended two Inches and nine Lines. He then tryed the ſame Experiment with *Salt-Petre* inſtead of *Salt Ammoniac* uſing the like Precautions, and the

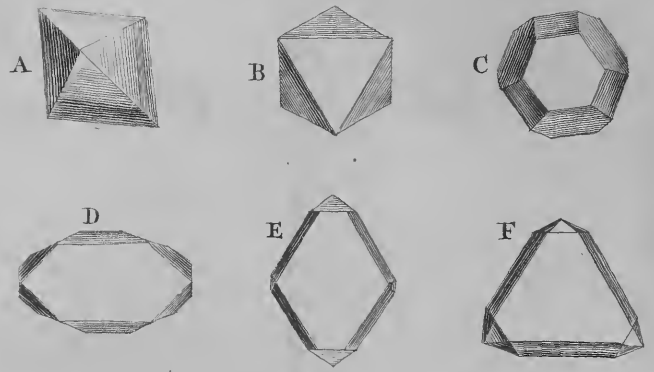
Liquor

Plate III. *pa. 112.* Alum.

Nº I.

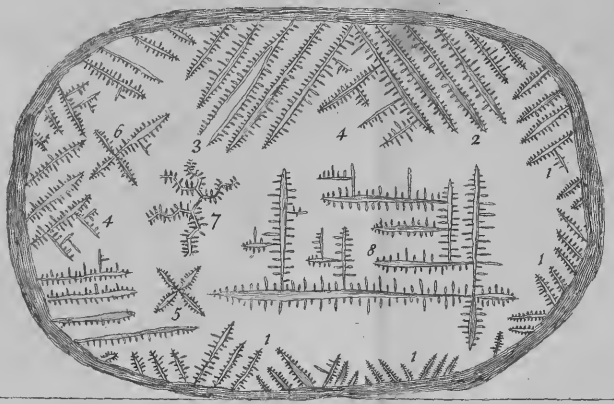


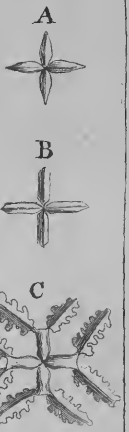
Christals of Alum.



Nº II. Borax. Christals.

Nº III. Salt Armoniac. Christals.





D. E. Baker del.

J. Mynde sculp.

Liquor deſcended one Inch and three Lines. *Vitriol* made it deſcend not quite an Inch, and *Sea-ſalt* but two Lines.

Monſieur *Homberg* orders a Pound of *Salt Ammoniac* and a Pound of corroſive Sublimate to be ſeparately reduced to Powder; then, after mixing them well together, he directs them to be put into a Glaſs Bottle, and a Pint and a half of diſtilled Vinegar to be poured thereon. This done, and the Compoſition being ſhaken together briſkly, it will become ſo cold, that a Man can but ill endure the Veſſel in his Hands even in the Summer-time. He ſays, that once, as he was making this Experiment, the Mixture happened to freeze; and Monſieur *Geoffroy* tells us the like Accident befel him once, on diſſolving a large Quantity of *Salt Ammoniac* in Water, ſome Drops on the Outſide of the Glaſs freezing: the wet Straw whereon it ſtood, was likewiſe faſtened thereto by Ice. But though he try'd many times he could never produce Ice again.

It is not my Purpoſe to enumerate the ſeveral Uſes of this Salt; I ſhall therefore conclude with obſerving, that it is extremely pungent, converts *Aqua Fortis* into an *Aqua Regia*, cauſes Tin to adhere to Iron, and diſſolved in common Water, is, I am informed, a Secret for the taking away of Warts.

CHAP. XVIII.

Salt of LEAD.

THIS Salt, which from the Sweetneſs of of its Taſte is uſually called *Sugar of Lead*, is prepared from Ceruſe or White Lead digeſted with diſtilled Vinegar in a Sand Heat to a Diſſolution: then evaporated till a Film ariſes, and ſet in a cold Place to cryſtalize. It is therefore Lead reduced into the Form of a Salt by the Acid of Vinegar, for Ceruſe is itſelf nothing elſe but the Ruſt of Lead corroded by Vinegar.

A little of this Salt diſſolved in hot Water, which it immediately renders milky, after ſtanding a Quarter of an Hour to ſubſide, is in a fit Condition for an Examination by the Microſcope. A Drop of it then applyed on a Slip of Glaſs, and held over the Fire to put the Particles in Action, will be ſeen forming round the Edge a pretty even and regular Border, of a clear and tranſparent Film or glewy Subſtance; *(See Plate* IV. N° I. *a a a a.)* which, if too ſudden and violent Heat be given, runs over the whole Area of the Drop, and hardens, and ſo fixes on the Glaſs, as not to be got off without much Difficulty. But if a moderate Warmth be made uſe of (which likewiſe muſt not be too long continued) this Border pro-

proceeds a little Way only into the Drop, with a Kind of radiated Figure compoſed of a Number of fine Lines, or rather Bundles of Lines, beginning from Centers in the interior Edge of the Border, and ſpreading out at nearly equal Diſtances from each other every Way towards the Exterior, *b b b b*. However it is obſervable that the Diſtances between the Lines are filled up with the glewy Matter, nor do the Lines themſelves ſeem detached therefrom, but are formed together with it. From theſe ſame Centers are produced afterwards a Radiation alſo inwards towards the Middle of the Drop, compoſed of Parallelograms of different Lengths and Breadths; from one and ſometimes both the Angles whereof there are frequently ſeen Shootings ſo exceedingly ſlender, that they are perhaps the beſt Repreſentation poſſible of a mathematical Line, which appear like a Prolongation of one or both the Sides. The Extremities of theſe Parallelograms are moſt commonly cut off at right Angles, but they are ſometimes alſo ſeen oblique. The whole of this Deſcription is ſhewn *c c c c*.

Centers with the like Radii iſſuing from them, and ſome of the glutinous Matter for their Root, are ſometimes formed in the Drop, intirely detached from the Edges, and in theſe it is very frequent to find a Sort of ſecondary Radii proceeding from ſome one

of the primary ones, and others from them again to a great Number of Gradations, forming thereby a very pretty Figure, the Repreſentation of which is given at D.

Give me Leave now to obſerve, that radiated Figures of Spar much reſembling theſe, and which probably owe their Form to the ſame Principles, are ſometimes found in Lead-Mines, of which I have at this Time a Specimen before me.

Notwithſtanding it may ſeem wandering from my Purpoſe, I ſhould think myſelf greatly wanting in my Duty towards Mankind, if I cloſed this Chapter without warning them of the Miſchiefs that may ariſe from taking this or any other Preparation of Lead internally, as the poiſonous Qualities of that Metal are not to be ſubdued or cured, and thoſe who have much to do with it ſeldom fail ſadly to experience its bad Effects. I am ſenſible this Salt has frequently been preſcribed in Quincies, Inflammations, and other Diſorders where great Cooling has been judged neceſſary: But Dr. *Boerhaave* declares he never knew it given with Succeſs, nor durſt himſelf ever preſcribe it internally, from his Knowledge that there is ſcarce a more deceitful and deſtructive Poiſon than this, which returns to Ceruſe as ſoon as the Acid is abſorbed therefrom by any thing it may meet with: and that it proves afterwards a moſt dangerous

and incurable Poiſon. Ceruſe, the fine white Powder of Lead, drawn with the Breath into the Lungs, occaſions a moſt violent and mortal Aſthma; ſwallowed with the Spittle it produces inveterate Diſtempers in the Viſcera, intolerable Faintings, Pains, Obſtructions, and at laſt Death itſelf: which terrible Effects are ſeen daily amongſt thoſe who work in Lead, but principally amongſt the White-Lead Makers *.

The Fumes of melted Lead are a Secret with ſome for the fixing of Quickſilver, and rendering it ſo ſolid that it may be caſt into Moulds, and Images may be formed of it, which when cold, are not only hard, but ſomewhat brittle, like *Regulus* of *Antimony* ‡.

CHAP. XIX.

Salt of Tin.

SALT of *Tin* is obtained in the ſame Manner as *Salt of Lead*, by digeſting the calcined Metal in diſtilled Vinegar, and ſetting it, when poured off, in a cool Place, for the Salts to ſhoot: which they will do in the Form of Cubes.

* *Boerhaave*'s *Chemiſtry* by *Shaw*, Vol. II. pag. 286.
‡ Vid. *Sherley on the Origin of Bodies*, pag. 18.

This cubic Salt being diſſolved in Water, and a Drop of the Solution placed under the Microſcope, in the Manner before directed, produces ſuch an Appearance at the Edges of the Drop as *a a* repreſent, conſiſting of Octaëdra, partly tranſparent, ſtanding on long Necks, at ſmall Diſtances from each other, with angular Shoots between them. At the ſame time ſolid and regular opake Cubes will be ſeen forming themſelves in other Parts of the Drop, *vid. b b. Plate* IV.

Theſe may be diſcerned when their magnified Size is extremely ſmall; and their Bulk increaſes under the Eye, continually, till the Water is nearly evaporated.

In the Midſt of the ſame Drop, and in ſeveral Places thereof, very different Figures will be likewiſe formed; particularly great Numbers of flat, thin, tranſparent, hexangular Bodies, *c c c*; ſome amongſt which are thicker, as *e*; and a few appear more ſolid, and with ſix ſloping Sides, riſing to a Point as if cut and poliſhed, *vid. d.*

The Figure *f* is compoſed of two high Pyramids united at their Baſe ‖. Some, in this kind of Form, are found truncated at one of their Ends, and others at both; but

‖ Dr. *Woodward* in his *Hiſt. of Foſſils*, Vol. I. p. 222, ſays, That Grains of Tin, and the Cryſtals from it, in the Mines, are quadrilateral Pyramids: and this ſeveral of them now before me prove.

but then they appear like flat Bodies, not having the four Sides of a Pyramid; as a few of them in the Drawing ſhew.—Several of the hexagonal Bodies may be obſerved with ſloping Sides, forming a ſmooth triangular riſing Plane, whoſe Angles point to three intermediate Sides of the Hexagon, *vid. g:* and ſome have a double Triangle, as another of the Figures ſhews.—*b* repreſents one of the ſolid Cubes.

Theſe Cryſtals are preſently deſtroyed by the Air, and converted into a Calx.

The Drawings in this Plate ſhew, that notwithſtanding the ſeeming Affinity of the two Metals, the Configurations of *Salt of Tin* bear not the leaſt Reſemblance to thoſe of Salt of Lead. In convulſive and epileptic Caſes, *Salt of Tin* is given internally with good Succeſs.

CHAP. XX.

ENS VENERIS.

AS Chemiſts give the Name of *Venus* to *Copper*, one would imagine their *Ens Veneris* to be a Preparation of that Metal: whereas it is in reality a Sublimation of the Salt of Steel or Iron * with *Sal Ammoniac*;

* *Green Vitriol* is uſually employed inſtead of *Salt of Steel.*

and therefore might be called *Ens Martis* with better Reason. It must however be acknowledged, that blue Vitriol was employed formerly instead of Salt of Steel; and *That*, being impregnated with Copper, rendered the Name less improper: but the *Ens Veneris* our Shops afford at present, has nothing of Copper in it.

It dissolves easily in Water, and gives to the Solution fated with it a Colour resembling that of Mountain Wine: which Colour its Crystals likewise retaining, appear (as they form before the Microscope) like the most beautiful *Chrysolites* or *Topazes*, seemingly cut with the greatest Elegance, in Shape as the *Plate* shews; and reflecting an extraordinary Lustre from their polished Surfaces, if the Candle be so shifted as to favour its being seen.

After the Solution has stood an Hour or two to settle, (for if used immediately its Foulness will prove inconvenient) a Drop thereof placed on a Slip of Glass, and warmed a little over the Candle, begins shooting from the Edges with solid transparent Angles, as (in the Drawing) *a a*. *Plate* IV. These, if only a gentle Heat has been given, will sometimes form, then dissolve, and afterwards form again.

The Crystals *b b* within the Drop, and underneath the same 1, 2, 3, 4, 5, 6, 7, are likewise best formed by a gentle Heat, and may

may be diſcovered in the Fluid, when their magnified Appearance is no bigger than a Pin's Point, gradually increaſing every Moment with regular Sides and Angles, poliſhed Surfaces, and the Brightneſs of precious Stones. If too violent an Heat be given, inſtead of ſuch Cryſtals, compound Figures will be formed, very ſuddenly, reſembling that at *c*, conſiſting of parallel ſtrait Lines, pointed with large ſolid Spear-like Heads of Cryſtal, along the Sides of which are placed, at right Angles, great Numbers of ſmall Cryſtals of the like Shape as the Drawing ſhews.—If the Heat has been little, though the ſame kind of Forms will be preſented, they will not appear till the Moiſture be nearly dryed away, when they will ſhoot out with amazing Quickneſs. Some ſmaller Compoſitions are alſo not unuſually ſeen, as at *d*.

But the Singularity of this Preparation is, that in ſome Part or other of the Drop, you will ſeldom fail to find a very regular and well-faſhioned two-edged Sword of Cryſtal, forming under the Eye, in ſuch Shape as *e* repreſents, though more exact and well-proportion'd : for ſuſpecting ſuch a Figure might be ſuppoſed imaginary, leſs Regularity has been, deſignedly, given it, than it will be really found to have. Sometimes two, three, or more, ſuch cryſtaline Swords are ſeen in the ſame Drop.

The

The regular Cryſtals of this Subject ſoon loſe the Sharpneſs and Elegance of their Form; but its compound Configurations, whoſe Beauty and Regularity are not to be conceived from Deſcription, though when the Fluid is nearly evaporated they ſeem blunted and indiſtinct, yet afterwards, when the Moiſture is quite gone, they recover their former Appearance, and may be preſerved a long while, by the Method before directed, *p.* 36. *Salt of Amber*, and ſome other Salts, loſe and recover themſelves after the ſame Manner.

CHAP. XXI.

Flowers of ANTIMONY.

THE *Flowers of Antimony* are collected in form of a white Powder, from the Fumes of burning *Antimony*, by means of a Glaſs Veſſel placed over it; and are ſuppoſed to contain the moſt active Salts and Sulphurs of that Mineral. The greateſt Part of theſe Flowers when they are well ſtirred about in Water, ſink to the Bottom thereof, leaving the Salts diſſolved and ſuſpended therein; and on placing a Drop of ſuch Water on a Slip of Glaſs, and giving it a gentle Heat, numbers of ſlender and

and extremely ſharp-pointed *Spiculæ* will be ſeen forming at the Edges of the Drop, as Plate IV. *a a a.* At the ſame time minute Particles of the Powder that were alſo ſuſpended in the Fluid, will be brought together by a mutual Attraction, and unite a little farther within the Drop, in Configurations reſembling a fine Moſs or Coralline, very beautiful and curious to behold: *vid. b b.*—The Middle of the Drop uſually remains clear and void of every thing.

Antimony (the *Stibium* of the Ancients) is found in many Countries: it is compoſed of glittering, brittle *Striæ* like Needles, the Colour of poliſh'd Steel; ſometimes running parallel to each other, and ſometimes lying in different Directions.—If taken as a Medicine in its native Condition, it is ſuppoſed very harmleſs, occaſioning no ſenſible Diſorder in the Body: but, after the Chemiſt has tryed his Art upon it, it becomes capable of purging or vomiting with great Violence, even in a very ſmall Quantity, and therefore ſhould be adminiſtred with much Caution. Its Operation is however extremely uncertain; the ſame Doſe at ſome times ſeeming to have no Effect at all, which at other times will operate upwards and downwards in ſuch Manner as to threaten the Patient's Life. This makes moſt Phyſicians afraid to meddle with the more elaborate

Prepa-

Preparations of it; though 'tis generally acknowledged, that if the Manner of their Operation was certain, or their Violence could be ſufficiently reſtrained, great Cures might be expected from them. Several *Noſtrums*, exhibited in very ſmall Doſes, under different Forms, and cryed up as almoſt univerſal Remedies, are believed, not without Probability, to be Preparations of this Mineral; from the like Uncertainty in their Operation, and the Violence wherewith they ſometimes act.

As this Uncertainty is too notorious to be denied, the Diſpenſers of theſe Medicines plead, that the Manner of their Operation depends intirely on the Conſtitution and Diſtemper of the Patient, but always tends to produce a Cure: for, ſay they, if vomiting be moſt neceſſary, the Medicine will prove emetic, and that juſt ſo long and with ſuch a Degree of Force as is requiſite to bring away the morbid Matter; on the contrary, if purging be more conducive to a Cure, the morbid Matter will be carried downwards; and if the Diſeaſe requires neither purging nor vomiting, neither will be excited, but the Diſorder will be cured by Perſpiration or ſome other inſenſible Way.—The Truth of this I have nothing at all to do with, but refer the Conſideration of it to thoſe to whom it more properly belongs: permit

mit me only to observe, that whatever Drug can operate as this does, must be capable of producing great Good or Harm in animal Bodies, according as its Powers can or cannot be directed or regulated: and consequently, whoever can discover Means to correct its Violence, and render it a perfectly safe Medicine, will deserve greatly of Mankind.

I shall conclude this Head with taking Notice, that the Star-like Shootings on the *Regulus of Antimony*, about which some Chemists make much ado, are nothing more than the natural Configuration of its Salts *.

CHAP. XXII.

Corrosive Sublimate, and Arsenic.

MERCURY, purified Nitre, (or the Spirit of it) calcined Vitriol, and Sea-salt, are the Ingredients from which *Corrosive Sublimate*, or *Mercury Sublimate*, is prepared; which is one of the most violent and

* *Regulus of Antimony* made up in a proper Form and Size, is called the *Perpetual Pill*, because it receives very little Diminution, tho' carried through the Stomach and Bowels fifty times, and will purge every time take it as often as you please. *Antimonial Cups* are made likewise of this Regulus, which for a long Time will render Wine put into them emetic.

and deadly Poiſons we know, lacerating and excoriating the Viſcera, by its keen and active Spiculæ, till a Gangrene and Death enſue; unleſs proper Remedies are immediately uſed to prevent it.

A Drop of the Solution of this Sublimate in Water, appears by the Microſcope to begin ſhooting from the Edges, as at *a*, *Plate* IV. immediately after which, different ſhaped Bodies are ſeen puſhing onward towards the Middle; ſome quite ſtrait and extremely ſharp like the Points of Needles, others widening themſelves towards their Extremities, and bending in ſuch Manner as to reſemble Razors with keen Edges: amongſt theſe many are jagged and indented like Saws, ſome on one Side only, and ſome on both Sides; all which Particulars I hope the Drawing will render intelligible, vid. *b b*. Thoſe that widen towards their Ends, ſtop their Progreſs, when advanced to the Condition repreſented: but ſuch as are ſtrait and tapering to a Point proceed very ſlowly towards the Middle of the Drop, and ſometimes much beyond it, forming long Spikes moſt exquiſitely ſharp-pointed, *vid. e e.*—A few extraordinary Figures appear ſometimes, ſerrated on both Sides, but in a contrary Direction, and ending with a very ſharp Point, as is ſhewn at *c*: Others are likewiſe ſeen, now and then, having four Sides, with

with keen Edges that run tapering to a Point, and form an Inſtrument like the long Head of a Spear exceedingly ſharp-pointed, as at *d*.

When the Water is nearly exhaled, another Sort of Configurations are formed very ſuddenly, conſiſting of innumerable little Lines diſpoſed in a very curious and wonderful Manner, as the two Figures *f f* endeavour to repreſent. And often (though not always) one or two Configurations ſhoot out, when one would think all over, reſembling what is ſhewn at *g*, but much more elegant and regular, and reflecting (I ſuppoſe from the extreme Thinneſs of the component Salts) with great Brilliance and Luſtre all the beautiful Colours of the Rainbow, if the Candle be placed to advantage. Which Circumſtance, together with the Shape of this Configuration, induces me to call it the *Peacock's Tail.* The Configurations *f f* reflect Priſm Colours alſo, but in a much leſs Degree of Perfection *.

The Compartment B is intended to ſhew, what happens frequently to this and many other Solutions, when a Drop is placed on a Slip of Glaſs, for Examination by the Microſcope: that is to ſay, ſome

* All theſe laſt mentioned Configurations appear like delicate Engravings, and afford the prettieſt Sight imaginable.

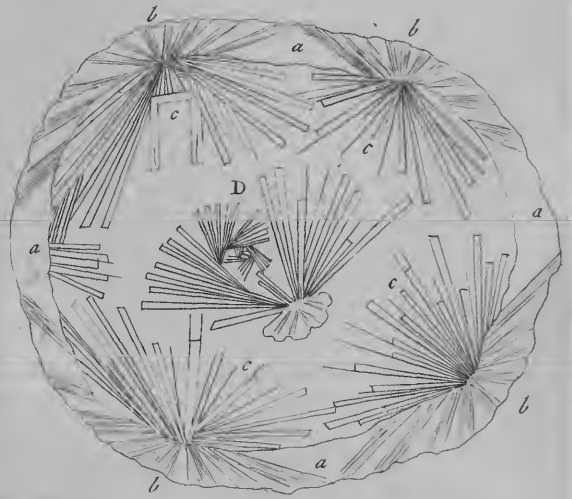
ſome ſmall Part of the ſaid Drop becomes ſo ſeparated from the reſt, as to make a ſort of ſmaller Drop, wherein a more minute kind of Configurations are formed, upon the ſame Plan as the larger ones in the Drop itſelf. And this the Reader may conceive better, by viewing the Picture before him, than by any Deſcription in my Power to give.

As *Corroſive Sublimate* and *Arſenic* are two Poiſons nearly alike in their Operation and fatal Conſequences, I think it beſt to treat of them together in this Chapter.

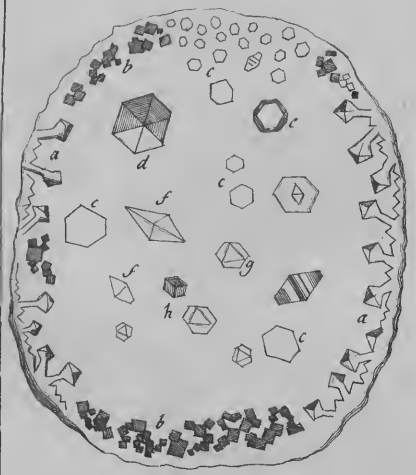
The Fumes that riſe from * *Cobalt*, in making of *Smalt* from that Mineral, being collected under the Appearance of a whitiſh Soot, that Soot, by a farther Proceſs, is converted into the common *White Arſenic*, which is what I now am ſpeaking of. It is brought to us in flattiſh Pieces of ſeveral Pounds Weight, and when newly broken appears tranſparent like Glaſs or Cryſtal,

* *Cobalt* is a hard and heavy mineral Subſtance, commonly of a blackiſh grey Colour, ſomewhat reſembling the Ore of Antimony, but leſs ſparkling and more difficult to break. Some of it has Spots of a Purple or rather crimſon Colour, which are called the *Flowers of Cobalt*. When roaſted or calcined in a reverberatory Furnace with certain Proportions of Pot Aſhes and common Salt, it produces a dark blue, glaſſy, or cryſtaline Matter called *Zaffer* or *Smalt*, and the Fumes collected in this Proceſs afford by different Management the *White*, *Yellow* and *red Arſenics*.

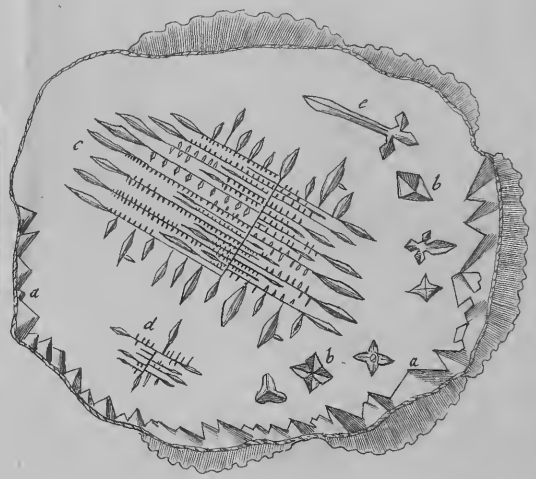
Plate IV. *pa.128.* Salt of Lead.



Salt of Tin.

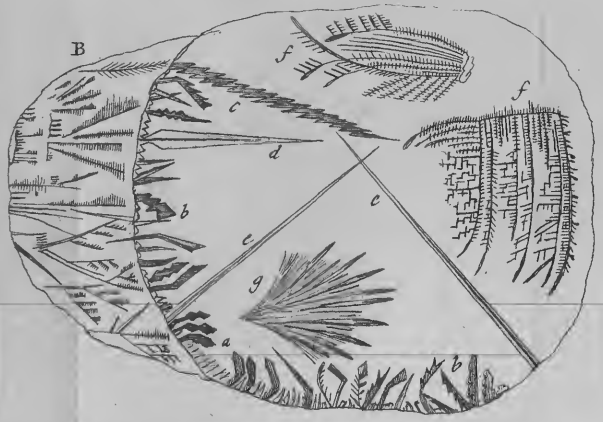


Ens Veneris.

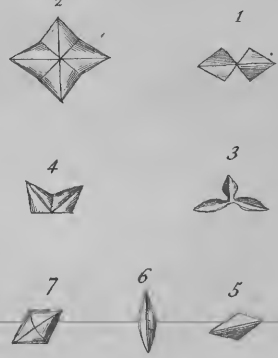


Flowers of Antimony.

Corrosive Sublimate.



Chrystals of Ens Veneris.



D.E.Baker del.

J. Mynde sc.

Cryſtal, with a browniſh Hue; but after a few Days it becomes opake, acquires a milky gloſſy Whiteneſs, and looks like white Enamel. When reduced to Powder it appears extremely white, and is frequently ſold in the Shops by the Name of *Ratſbane*.

Notwithſtanding this Subſtance certainly abounds with Salts, as its cryſtaline Appearance and its cauſtic and corroſive Qualities ſufficiently evince, they are ſo ſheathed or locked up (as the Chemiſts expreſs themſelves) in their Sulphurs, that they are very difficult to be ſeparated and brought to view. Dr. *Mead* ſays, White Arſenic is intirely ſoluble, if one Part of it be ſufficiently boiled in fifteen Parts of diſtilled or Rain Water †, which (with what I ſhall mention preſently) gives me reaſon to imagine there may be a Difference in Arſenic, from perhaps a different Way of preparing it; for notwithſtanding I have boiled ſmall Quantities, for a long while together, in much larger Proportions of Water, to the Conſumption of the greateſt Part, I always found moſt of the Arſenic at the Bottom undiſſolved. Nor amongſt the Chemiſts could I ever obtain any of its Salts, which I was greatly deſirous to examine by the Microſcope *.

† *Mead* on Poiſons, 3d Edit. pag. 217.

* A Phyſician of great Eminence gave me once a ſmall ſemi-tranſparent brown Maſs, ſhot out in Angles, which a Chemiſt

Sometimes, indeed, in a Drop of the Water wherein Arſenic has been boiled, I have diſcovered a very few ſingle Octaëdra, conſiſting of eight triangular Planes, or two Pyramids joined Baſe to Baſe; which undoubtedly is the true Figure of its Cryſtals, as I have ſince been fully convinced by the Aſſiſtance of an ingenious Friend, who found means to diſſolve an Ounce of the *white cryſtaline Arſenic* in about three Pints of Water, of which, after evaporating a conſiderable Part, he brought a Phial-full to me. It was then a very clear and ponderous Liquor, without any Appearance of Cryſtals: but in a few Days, I found the Sides of the Phial, even as high as the Surface of the Liquor, pretty thickly covered with very minute Cryſtals, adhering firmly to the Glaſs, ſo as not eaſily to be removed, but diſtinct and ſeparate from one another. On examining them with Glaſſes, I found them to be Octaëdra, uncommonly hard and inſoluble. After near ſix Months I don't perceive their Size to be at all inlarged, or their Number to be increaſed. A Drop of the Solution,

a Chemiſt had preſented to him as the true Salt of Arſenic, and I had great Hopes by this to have gratified my Curioſity: but when I came to try it, I found it abſolutely inſoluble, even in boiling Water, after its being reduced to Powder; and from its Appearance, its Hardneſs, and other Circumſtances, I am very ſuſpicious it was no other than common Spar.

Solution, examined on a Slip of Glaſs, either heated over a Candle, or left to evaporate of itſelf, notwithſtanding its being ſated with the Particles of Arſenic, produces no Configurations, and hardly any Cryſtals, leaving only a white Powder behind it upon the Glaſs: whoſe Particles, whilſt the Water gradually evaporates, appear like minute Globules, even ſmaller than thoſe of the Blood.

This *White Arſenic* is much more dangerous than the yellow or red, being a deadly Poiſon to all living Creatures: the Symptoms it brings on are much the ſame as thoſe of *Corroſive Sublimate, viz.* Sickneſs, Fainting, Convulſions, cold Sweats, intolerable Heat and Thirſt, Eroſion of the Stomach and Inteſtines, Inflammation, Gangrene, and Death. But its Action is ſlower than that of Sublimate, for its Salts are ſo ſheathed by its Sulphurs, that they begin not to operate, till thoſe Sulphurs become rarified by the Heat of the Body, and ſet the Salts at Liberty; inſomuch that a Patient may be ſaved after it has been ſwallowed half an Hour, by drinking large Quantities of Olive-Oil, or melted freſh Butter, or Lard, if Oil be not at hand, till by Diſcharges upwards and downwards, an Abatement of the Symptons ſhews the Poiſon to be carried off. Salt of Tartar diſſolved in Broth or Water, is alſo greatly com-

mended in this dangerous Caſe, along with the foregoing Remedies, as a Corrector of this Poiſon, and ſo likewiſe is Milk. The ſame Method is adviſeable where Sublimate has been ſwallowed, but then it muſt be employed very ſpeedily, or no Relief can be expected. After either of theſe Poiſons has been diſcharged, drinking Milk for a few Days, and a gentle Purge or two, are very proper to compleat the Cure *.

The

* Dr. *Blair*, in his Letter to Dr. *Mead* on the Effects of *Arſenic* upon human bodies, gives two remarkable Caſes; the one of a Woman, who was killed by this Poiſon mixed with Flummery; which ſhe eating about eleven o'Clock at Night, was ſeized immediately with violent Purgings and Vomitings, that continued till four o'Clock in the Morning, when ſhe died convulſive. The Poiſon had been ſo well wrapt up in the Flummery, that on her being opened the Oeſophagus was no ways altered: but the Doctor was ſurprized to find the Stomach ſo full of Liquor, having been informed ſhe had eat or drank very little the Day before the Poiſon was given. It contained a greeniſh Subſtance, without any Colour or Appearance of ſuch a digeſted Maſs as uſes to be in the Stomach, with ſeveral thick Coagula about the bigneſs of Walnuts, ſuſpending ſome ſmall Quantities of a whitiſh groſs Powder. When this Liquor was emptied, he found reddiſh and blackiſh Striæ all over the Pilorus, being ſo many inflamed Lines reſembling the Branchings of Blood-veſſels, upon which the groſs whitiſh hard Powder lay in ſuch Quantitiy, that after being well dried it weighed between a Scruple and half a Dram. All along the Inteſtines, as he laid them open down to the Anus, he found ſo much of the ſame kind of Liquor, without either Colour, Conſiſtence, or Smell of an Excrement, as filled a Quart Bottle: which ſeemed extraordinary, conſidering the great Evacuations before her Death. He infers, that the Glands throughout the whole

Primæ

The Fumes or Steams of Arſenic are exceedingly pernicious, and commonly diſtinguiſh themſelves by an abominable ſtinking Smell like Garlic; tho' *Otto Tachenius* ſays, in his *Hippocrates Chemicus*, that after many Sublimations of Arſenic, on opening the Veſſel, he ſucked in ſo grateful and ſweet a Vapour that he greatly admired it, having never experienced the like before: but in about half an Hour, his Stomach began to ake and became contracted, a Convulſion of all his Limbs ſucceeded, he made bloody Urine with incredible Heat, was ſeized with

Primæ Viæ muſt have been moſt violently compreſs'd, to ſqueeze ſuch Quantities of Liquor into the Stomach and Inteſtines.

The other Caſe is of a Lady, who on taſting (by Miſtake) only ſo ſmall a Quantity of *White Arſenic* as adhered to the Tip of her Finger, found herſelf within two Hours in great Diſorder, grew faint, fell in a Swoon, and loſt her Senſes before ſhe could be laid in Bed. A Phyſician being called, preſcribed an Emetic, which made her vomit a large Quantity of ſuch Sort of greeniſh Liquor as in the former Caſe; after which ſhe voided by Stool ſeveral Globules of greeniſh Coagulum, of the Bigneſs, Colour, and nearly the Conſiſtence of Pickled Olives. Theſe Diſcharges being over, and Alexipharmics given, ſhe ſweated plentifully, and ſlept well, and when ſhe awaked her Skin was ſpeckled with livid and purpliſh Spots. She recovered in a few Days, and became perfectly well. The Doctor obſerves, that theſe greeniſh Coagula are what *Arſenic* uſually produces, when internally given; the Knowledge of which may be of uſe to thoſe who may have occaſion to open Bodies on Suſpicion of their having been poiſoned thereby. See *Blair*'s *Miſc. Obſervations*, pag. 62.

Cholic Pains and cramped all over for an Hour or two; when these ugly Symptoms were taken away by his drinking Milk and Oil, and he became indifferently well; they were followed however by a slow Fever like an Hectic, which stuck by him the whole Winter, and of which he recovered very slowly by a proper Regimen in Diet †.

The extreme Subtilty and Penetrability of these Steams are remarkably manifest by their surprizing Effect in the Experiment of

† *Glauber* tells us, in his Treatise *de Salibus*, that *Cobalt* and *Arsenic*, tho' violent Poisons, are yet harmless unless taken in Substance, but if exalted by a Sublimation with Salts and rendered volatile, the very Fumes of them will kill, as is well known to those who prepare the Water called *Aqua gradatoria* from a Mixture of Vitriol, Nitre and Arsenic, the least Vapour or Fume whereof instantly affects the Heart with the most horrid Tremors, and exceedingly disorders the Brain itself: a Candle will likewise be nearly extinguished in the saline Fumes thereof.

In Dr. *Mead's Mechanical Account of Poisons*, 3d Edit. pag. 225, are these Words, "I had once in my Posses-"sion, given me by an ingenious Chemist, a clear Li-"quor, which though ponderous, was so volatile, that it "would all fly away in the open Air without being "heated; and so corrosive, that a Glass Stopple of the "Bottle which contained it, was in a short Time so "eroded, that it could never be taken out. The Fume "from it was so thin, that if a Candle was set at some "Distance from the Bottle, upon a Table, the Heat would "direct its Course that Way; so that it might be poisonous "to any one that sat near to the Light, and to nobody "besides." The Doctor very humanely conceals this Composition, lest an ill Use might be made thereof.

of the Ink called Sympathetic ‡. A Grain of Arſenic will alſo convert a Pound of Cop-

 per

‡ As ſome of my Readers may poſſibly not know the Experiment here referred to, I ſhall give it by Way of Note, which thoſe acquainted with it may if they pleaſe paſs over.

Orpiment half an Ounce, and one Ounce of Quicklime, being powdered ſeparately, then mix'd together, and put into a Matras with five or ſix Ounces of Water, ſtop the Veſſel cloſe, and digeſt in a gentle Sand Heat for ten or twelve Hours, ſhaking the Mixture often. The Liquor, when ſettled, will be very clear.

This being prepared, write, with a ſtrong Solution of *Saccharum Saturni* made in common Water, on a Piece of clean Paper, and when it is dry nothing will be ſeen at all. Put the Paper with this inviſible Writing between the very beginning Leaves of a Book; then with a Bruſh or Piece of Spunge, dipt in the Liquor prepared with Orpiment, wet another Paper, and place it at the End of the ſame Book, oppoſite to the firſt Paper. Shut the Book nimbly, and with your Hand ſtrike on it two or three ſmart Blows; and if it be very thick ſqueeze it in a Preſs, or ſit upon it a few Minutes; after which, on opening the Book, you'll find the inviſible Writing black and legible, by the ſubtile Penetration of the Steams of the Orpiment through all the Leaves.

Quench burning Cork in Spirit of Wine, and when 'tis finely powdered make Ink, by mixing a ſufficient Quantity of it in Water a little thickened with Gum. Write on a Paper with the Solution of *Saccharum Saturni*, and when 'tis dry and inviſible, write again upon the ſame Place with your Cork and Water which will appear like common Ink; when 'tis dry rub it over with ſome Cotton wetted in the Preparation of Orpiment, and immediately the Writing that was viſible will diſappear, and the inviſible Writing will preſent itſelf very legible inſtead thereof. Theſe are pretty Experiments, which I ſeveral times have tried; but they ſhould be made in the open Air, and with great Caution, the Fumes of the Orpiment ſtinking moſt abominably, and being productive of great Miſchiefs if taken into the Lungs.

per into a beautiful Resemblance of Silver, but renders it brittle at the same Time. *Otto*

ARSENIC being the Poison most commonly made use of by wicked People to destroy others, and by despairing Wretches to put an End to their own Lives, I shall I hope be excused, for adding this Note of Instruction how to make Tryal of any Substance suspected of being *Arsenic:* and likewise how to judge of the Symptoms it produces when taken; collected from the recent unhappy Case of Mr. *Blandy*.

This Gentleman was poisoned by Arsenic, given him by his own Daughter in Water Gruel; at the Bottom of a Pan of which a Servant Maid finding an unusual white gritty Substance, and suspecting Mischief, from having seen her Mistress stirring something into it, she shewed it to an Apothecary, who saved a little Quantity of the Sediment, which was dryed, and examined by Dr. *Addington*.

The Doctor's Account of *White Arsenic* upon the Trial of Miss *Blandy*, was, that when powdered it has a Milky Whiteness, is gritty and almost insipid. Part swims on the Surface of cold Water like a pale sulphureous Film, but the greatest Part sinks to the Bottom, and remains there undissolved. Thrown on red hot Iron, it does not flame, but rises intirely in thick white Fumes, which have the Stench of Garlic, and cover cold Iron held over them with white Flowers. The Powder he examined did exactly the same.

He boiled ten Grains of powdered Arsenic in four Ounces of clean Water, which he filtered, divided into five equal Parts, and put into as many Glasses. — On pouring into the first Glass a few Drops of Spirit of Sal Ammoniac, it threw down a few Particles of a pale Sediment. Some Lixivium of Tartar poured into the second, produced a white Cloud, hanging a little above the Middle of the Glass. Strong Spirit of Vitriol poured into the third, made a considerable Precipitation of a lightish coloured Substance, which hardened into glittering Crystals, sticking to the Sides and Bottom of the Glass. Spirit of Salt poured into the fourth, precipitated a lightish coloured Substance. Syrup of Violets in the fifth, produced a beautiful pale green Colour. — Ten Grains of the Sediment from the Gruel, tryed in the same Manner, afforded the same Appearances exactly.

The Symptoms produced by this Poison in Mr. *Blandy*, were burning and pricking in the Tongue, Throat, Stomach, and Bowels, Sickness, Gripings, Vomiting and Purging, bloody

Otto Tachenius ſays, that Silver may be obtained from Tin by Arſenic.

CHAP.

bloody Stools, Excoriation of the Fundament, Swelling of the Belly, exquiſite Pains and Prickings in every external as well as internal Part of the Body, which he compared to an infinite Number of Needles darting into him all at once. Uneaſineſs in the Mouth, Lips, Noſe and Eyes; Lips dry and rough with angry Pimples on them, inſide of the Noſtrils in the ſame Condition, the Eyes a little Bloodſhot; cold Sweats, Hiccup, extreme Reſtleſsneſs and Anxiety, low trembling intermitting Pulſe, difficult unequal Reſpiration, Difficulty of Speech, Inability of Swallowing, and (the Conſequence of all theſe cruel Symptoms) Death.

Dr. *Addington* and Dr. *Lewis* on examining the dead Body, found it in the following Condition, *viz.* The Back, hinder Part of the Arms, Legs and Thighs, were livid. The Fat on the Muſcles of the Belly of a looſe Texture, inclining to a State of Fluidity; the Muſcles themſelves pale and flaccid. The Cawl yellower than natural, and on the Side next the Stomach and Inteſtines, browniſh. The Heart variegated with Purple Spots; and no Water in the Pericardium. The Lungs like Bladders filled with Air, and blotted as it were in ſome Places with pale, but in moſt with black Ink. The Liver and Spleen much diſcoloured: the Liver looked as if boiled, but that Part which covered the Stomach particularly black. The Bile fluid, of a dirty yellow inclining to red. The Kidneys ſtained all over with livid Spots. The Stomach and Bowels inflated, and appearing before any Inciſion, as if pinched and extravaſated Blood had been ſtagnated between their Membranes. They contained nothing, as far they were examined, but a ſlimy bloody Froth: their Coats remarkably ſmooth, thin and flabby. The Wrinkles of the Stomach totally obliterated: its internal Coat and the Duodenum prodigiouſly inflamed and excoriated.——Vid. *Miſs Blandy*'s Tryal, Folio, pag. 12, 13, 14, 15.

As *Arſenic* is not uſed in Medicine, it would be well if the Apothecaries and Chemiſts did not keep it in their Shops. Selling now and then a Pennyworth to kill Rats, (and even in doing that many ſad Accidents have happened) can ſurely induce no good Man to riſk the Poſſibility of putting this horrid Poiſon into wicked Hands.

CHAP. XXIII.

Salt of Amber.

THE pretty Shootings of this extraordinary Salt are exceedingly entertaining, though its Progreſſions are ſo very ſlow, that ſome Patience is neceſſary to wait for and attend to the whole Courſe of its Configurations: but a curious Obſerver will find from it at laſt a Pleaſure ſufficient to reward his Attention.—Its firſt Shootings at the Edge of the Drop, after it has been held for a few Seconds over the Flame of a Lamp or Candle, appear irregular, as at *a a*, *Plate* V. Some Figures puſh out ſoon after, beyond the reſt, and are curved and tapering to a Point, as *b b*. Very elegant Figures will be ſeen forming themſelves in other Places at the ſame time, and reſembling Sprigs of Fir or Yew: Numbers of theſe riſe together, each having a main Stem very thickly beſet with little Shootings from Top to Bottom, in ſome on both Sides, but in others on one Side only; which Difference will be underſtood by a View of the Figures *c c*. The downy Feathers of Birds appear in the ſame Kind of Form when examined by the Microſcope. As the Progreſſion goes on, Branches will be found iſſuing from the Sides of the former Shootings, *vid. d*: and in ſome Places of the Drop ſeveral Gradations

tions of Branchings will be perceived to ſucceed one another, to divide and ſubdivide after a moſt wonderful Order, repreſenting at the laſt a Winter Scene of Trees without Leaves, a Specimen of which is ſhewn at *e*. — The laſt Action of this curious Salt produces Figures exquiſitely delicate, bearing no Reſemblance to any thing that preceded, but appearing like the Flouriſhes or Engravings of a Maſterly Hand, in the Manner repreſented at *ff*. This Part of the Operation begins not till the Water is nearly exhaled, and whilſt it is performing the Scene appears a good deal confuſed; but after waiting till the Water is intirely dryed away, a thouſand Beauties will preſent themſelves perfectly diſtinct and clear; for the Configurations of this Salt do not break away, or melt in the Air, as moſt others do, but may be preſerved on the Glaſs Slip for a long while afterwards, if ſo be nothing is ſuffered to rub them off.

It would give me great Pleaſure, was it poſſible, from the Configurations of this Salt, to trace out, with any Degree of Certainty, the Generation or Production of Amber; a Subject about which *Naturaliſts* are exceedingly divided and perplex'd: Some ſuppoſing it an animal Subſtance, others a reſinous vegetable concreted Juice, and others a natural Foſſil or Mineral: but the Shootings of its Salt are ſo very different from every other Kind, that

they afford little or no Ground on which to raiſe a Conjecture: however, the general Figures round the Edge have I think a Sort of mineral Character, and the Feather-like Bodies tend a little towards the Shootings of ſome of the Vitriols. The curved ſingle Lines *ff*, which appear like Drawings with a Pen, are ſo peculiar to this Salt, that, for want of finding them elſewhere, one can form no Judgment from whence they derive their Form; and the Caſe is the ſame as to thoſe Shootings which reſemble naked Trees. I ſhall not pretend therefore to infer any thing from theſe Figures: but, before I intirely quit the Subject, ſhall preſent a few *Queries* to the Conſideration of my curious Readers.

Quere 1. Does not Amber when analized, afford a conſiderable Quantity of *Oil*, in Smell, Colour, Inflammability and Conſiſtence like the White, or rather Amber-coloured *Naptha*, a Proportion of *Acid Salt*, and a *Caput Mortuum* or Earthy Subſtance? and if ſo, does it not ſeem probable, that ſuch a bituminous Oil fixt by an acid Salt, with more or leſs of an Earthy Subſtance, is really the Compoſition of Amber *?

Quere

* In the Diſtillation of Amber there firſt riſes a thin limpid Oil, then an Oil yellow and tranſparent, which is ſucceeded by a volatile acid Salt and a red Oil ſomewhat cloudy: a groſs fat Oil like Turpentine comes over next, and laſt of all a thick black Matter. At the Bottom remains a ſmall Quantity of a *Caput Mortuum*. Vid. *Boerhaave*'s Analyſis of Amber, Vol. IId of his Chemiſtry, Proceſs 87. *Hartman* obtained an Ounce of volatile Salt from 1 ℔ of white Amber, whereas 1 ℔ of yellow afforded ſcarce a Dram.

Quere 2. If it be inquired, where theſe Materials are to be found, and how they can be brought together? may it not be anſwered, that in ſome Countries, and particularly in *Perſia*, near the *Caſpian* Sea, there are Springs where *Naptha* riſes out of the Bowels of the Earth; and that the Ground thereabouts is ſo ſaturated therewith, that, on ſcraping off the Surface, and applying a Candle near it, a Fume ariſing therefrom immediately takes Fire, and continues burning, with a clear and conſtant Flame, until it becomes extinguiſhed by throwing Earth upon it, or ſmothering it by ſome other Means *? If therefore, ſuch bituminous Oil

* Two Letters now lie before me, with Accounts of theſe *Naptha* Springs; one from Dr. *James Mounſey*, Phyſician to the Army of the *Czarina*, the other from *Jonas Hanway*, Eſq; both Gentlemen, who by their Travels, their Reſidence in *Muſcovy*, and their Acquaintance with ſeveral People who have been upon the Spot, have had great Opportunities of becoming perfectly informed of every thing relating to this Subject; and whoſe Judgment and Veracity may be depended on. Both their Accounts agree, that on the Weſtern Coaſt of the *Caſpian Sea*, not far from the City of *Baku*, there is a large Spot of Ground, where, on taking off 2 or 3 Inches of the Surface of the Earth, and then applying a live Coal, the Place uncovered catches Fire, even before the Coal touches the Ground, and ſends forth a light blue Flame, which goes not out unleſs it be ſmothered by throwing Earth, or ſomething elſe upon it. This Flame makes the Earth hot, but does not conſume it. If a Tube (even of Paper) or a Reed be ſet about two Inches in the Ground, and made cloſe below with Earth, on touching the Top of it with a live Coal, and blowing, a Flame immediately iſſues forth, without burning either the Reed or Paper, provided the Edges be covered

Oil be found, and in ſufficient Quantity, our next Enquiry will be concerning the Acid Salt: as to which, are not the Chemiſts pretty generally agreed, in ſuppoſing, that what they call a *Vague Acid* (whereby they mean, if

covered with Clay. This Method ſupplies the want of Candles in their Houſes. Three or four of theſe Canes will alſo boil Water in a Pot, and they dreſs their Victuals with it. The Flame may be blowed out like that of a Lamp, but otherwiſe it continues burning; it ſmells ſomewhat ſulphureous, or rather like *Naptha*, but very little offenſive. The Ground is dry and ſtony, and the more ſtony the Ground the ſtronger and clearer the Flame. Near this Place they dig Brimſtone, and here are alſo *Naptha* Springs. But the chief Place for *Naptha* is *Swieten* Iſland, a ſmall Tract of Land on the Weſtern Coaſt of the *Caſpian* Sea, and uninhabited, except at ſuch Seaſons as they fetch *Naptha* from thence: which the *Perſians* load in their wretched Embarkations without Barrels or any other Veſſels, ſo that ſometimes you ſee the Sea covered with it for Leagues together. The Springs boil up higheſt in thick and heavy Weather, and the *Naptha* ſometimes takes Fire on the Surface, and runs lighted or burning into the Sea in great Quantities, and to great Diſtances. In clear Weather it does not bubble up above two or three Feet. People make Ciſterns near the Springs, into which they convey what overflows by Troughs, taking off the *Naptha* from the Surface, under which there is a Mixture of Water or ſome heavier Fluid. The greateſt part is of a dark grey Colour, very unpleaſant to the Smell, but uſed in Lamps by the poorer Sort. There are alſo Springs of black *Naptha*, which is thick, and on Diſtillation grows not clear but yellow; but the moſt valuable is the white *Naptha*, which is naturally clear and yellowiſh, and bears a great Price. The *Ruſſians* drink it as a Cordial, but it does not intoxicate: it is uſed alſo for Pains or Aches, and is carried into *India* as a great Rarity, where they make with it the moſt beautiful and laſting *Japan* that has ever yet been known.

What the *Indians* call the *Everlaſting Fire*, lies about ten Engliſh Miles, N.E. by E. from the City of *Baku*, on dry rocky Ground. There are ſeveral ancient Temples built with Stone, ſuppoſed to have been all dedicated to Fire; moſt of them

are

if I understand them aright, a volatile subtle Vapour, Fume, or Spirit) exists in the Bowels of the Earth, and throughout the Atmosphere near the Surface thereof; and that by pervading, intermixing, or concreting with different Substances, it composes Vitriol,

are low arched Vaults, from 10 to 15 Feet high. Amongst the rest there is a Temple in which the *Indians* now worship; near the Altar, about three Feet high, there is a large hollow Cane, from the End of which issues a Flame, in Colour and Gentleness not unlike a Lamp that burns with Spirits. The *Indians* affirm, this Flame has continued burning some thousands of Years, and believe it will last to the End of the World, and that if it was resisted or suppressed in this Place, it would rise in some other. By the Number of Temples it is probable here were formerly a great Number of Worshippers of Fire, as well *Indians* as *Persians:* they are called *Gouers.* At present here are only about twenty Persons, who reside constantly and go almost naked. In Summer it is very hot, and in Winter they dwell within doors, and can keep what Fire they please in the Manner above described: they live upon Roots and Herbs for the most part, and are supposed to attend as Mediators for the Sins of many who are absent: and by their Application to this Fire, in which the Deity is supposed to be present and visible, they attone for the Sins of others. A little way from the Temple just now mentioned, near *Baku,* is a low Cliff of a Rock, in which there is an horizontal Gap 2 Feet from the Ground, between 5 and 6 long, and about 3 Feet broad, out of which issues a constant Flame, much of the Colour mentioned already, being a light blue. It rises sometimes 8 Feet high, but is more low in still Weather. They don't perceive the Rock wasles in the least. This also the *Indians* worship, and say it cannot be put out. About 20 Yards on the Back of this Cliff is a Well, in a Rock 12 or 14 Fathoms deep, with exceeding good Water.

The curious Particulars contained in this Digression will 'tis hoped excuse its being inserted.

I received with these Letters some of the white *Naptha,* which in Colour, Smell and Taste resembles much the finest kind of Oil of Amber.

Vitriol, Alum, Nitre, and ſeveral Metallic and Mineral Bodies? May it not then be imagined poſſible for this ſame acid Vapour ſo to mix with and conſolidate ſuch bituminous foſſil Oil, or Naptha, as thereby to produce Amber?

Quere 3. Is there any thing in the Appearance of Amber, or in the Places where it is found, that may conduce towards forming ſome probable Conjecture concerning the Production of this Body * ?

Quere 4. Do not the ſeveral Species of Inſects found in Amber, prove, beyond all Diſpute, that it muſt have been in a fluid State at the Time thoſe Inſects were intangled in it? Are not the Springs or Oozings

* We are told, that where Amber is met with in Quantity, there is likewiſe conſtantly an Abundance of Vitriol. No Country yet known affords more or better Amber than *Pruſſia*, where it lies, as *Hartman* ſays, in a Kind of Stratum or Bed, intermixt with a Subſtance reſembling foſſil Wood or Bark, but whoſe Origination he imputes to a fat bituminous Earth: Vitriol and Bitumen are alſo here in Plenty, and he was informed there are Springs of Oil riſing out of the Ground; from all which Circumſtances put together, his Concluſion is, that the Exhalations of Bitumen (from a ſubterraneous Heat) are collected into Drops; that the ſame Heat pervading the neighbouring Salts, carries their Effluvia along with it, and mixes them with the bituminous Drops; whence he ſuppoſes, that the ſaline Spiculæ fix the Bitumen and produce Amber, which is more tranſparent, better ſcented, and firmer, according to the Purity and Proportion of the bituminous and ſaline Exhalations. Vid. *Phil. Tranſ.* N° 248. May not ſome of the foſſil Oil here mentioned be as eaſily ſuppoſed to have been fixt by the ſaline Effluvia or Spiculæ?

ings of Naptha out of the Earth in Places where Insects might be likely to fall into it? Supposing which, might it not perhaps have been hardened or congealed by the acid Vapour soon after their being so intangled? though that is not absolutely necessary, since Naptha will preserve Animal Bodies a great Length of Time. Is it not found on Tryal, that the Wings, Horns, Legs, *&c.* of very small Creatures spread and extend themselves much better in Naptha, or fine Oil, than in Water or any watry Fluid? and may not this account, in some measure, for the Perfection in which some very small Insects appear, when embodied in this Substance?

Quere 5. As the Earth affords bituminous Fluids different in Colour, Consistence and Purity, may not white Naptha (so called, tho' of a pale yellow,) which is the most pure of all, be supposed capable of being concreted into the best and cleareſt Amber? may not a coarser and browner Naptha compose Amber more indifferent? and may not a black Kind be converted by the same Chemistry of Nature into Jet and Asphaltum?

Quere 6. Is it wholly improbable that some bituminous Juice, or fossil Pitch, mixed and concreted with Earth, or perhaps some other Matter, may be the Composition of Coal? and should it be inquired

where an acid Spirit can be found for the fixing and conſolidating theſe Principles? do not the *Choak Damps* in moſt Coal Pits prove the Exiſtence of ſuch a Spirit within the Bowels of the Earth? do not the *Fire Damps*, frequent in the ſame Pits, likewiſe prove the Abundance of a bituminous Vapour inflammable like Naptha.

Quere 7. Do not the Brittleneſs and Lightneſs of Coal, Jet, and Amber, ſomewhat countenance the Opinion of their being of an oily and bituminous Compoſition? and if ſo, what Fluids does the Earth afford ſo likely to conſtitute theſe Subſtances as * *foſſil Pitch, Petroleum, Oleum Terræ*, and the different Sorts of *Naptha?*

CHAP.

* Captain *John Poyntz* in his Account of the *Iſland of Tobago*, p. 38. ſays, "*Green Tar* iſſues out of the Earth from "the *Munjack Rocks*, and is commonly gathered after a "Shower of Rain, by ſkimming it off from the Surface of "Water: then putting it into a great Gourd, or ſuch "like Veſſel, that has an Hole at the Bottom, they ſeparate "the Oil from the Water, by ſuffering the Water to ſlide "gently out, but when the Oil appears, they cautiouſly ſtop "and preſerve it for ſeveral Uſes, as to burn in Lamps, &c. "The *Munjack* is nothing elſe than a Confirmation or Coa-"gulation of the Tar (we ſpoke of) into a more ſolid "Body; which *Munjack* were it in a frigid, as it is in "the torrid Zone, would be abſolute Coal, ſuch as we "burn in *England*."

CHAP. XXIV.

Of SCARBOROUGH SALT.

WHAT I am now about to treat of under the Name of *Scarborough* Salt, was bought at one of the principal Water Warehouſes in *London*, at a good Price; and was affirmed by the Seller to bs a true and genuine Salt prepared from the *Scarborough* Well.

Some of this being diſſolved in Water, a Drop of the Solution begins ſhooting from the Edges: firſt of all, in Portions of quadrilateral Figures, much like thoſe of common Salt; but their Angles inſtead of 90 are of about 100 Degrees. Theſe Figures ſhoot in great Numbers round the Borders of the Drop, having their Sides as nearly parallel to one another as the Figure of the Drop will allow: ſome proceed but a little Way, others farther before they renew the Shoot, *vid. a a*, *Plate* V. In ſome Places they appear more pointed and longer, as at *b*, and ſometimes inſtead of the Diagonal, one of the Sides is ſeen towards the Edge, and the other ſhooting into the Middle, as *e*.

The inward Configurations ſeem to owe their Forms moſtly to Vitriol, and are all produced by the ſame Method of Shooting: though ſome proceed from the Figures al-

ready formed at the Edges, and others from original Points rising in the Fluid, and intirely detached from the Sides of the Drop. The former are produced by the sudden Elongation of such Figures as *b*, or *c*, into one long Spike or Stem, which in its Progress sends forth *Spiculæ* from its Sides, ranged close to one another, sometimes nearly at right Angles to the main Stem, as at *e*, and at other times obliquely thereto, those on the one Side shooting upwards, and those on the other downwards, in regard to the Foot of the Stem, as at *d*: the whole Number of the *Spiculæ* on each Side of the Stem forming a right angled, or an oblique angled Triangle. From the lowest of these *Spiculæ* are frequently seen others of the same Kind proceeding, but their Direction, in respect to the Branch they rise from, seems not wholly correspondent to the Direction of the said Branch in respect to its main Stem, being sometimes alike and sometimes unlike thereto, *vid. d e.*

The other Figure which the Middle produces is of a like Kind with those last described, but shoots from a single detached Point (for the most part) into four Branches, which are generally tho' not always oblique to one another, as at *f.*

CHAP.

CHAP. XXV.

Cheltenham Salt.

WHEN this Salt is prepared for Examination by Solution, its firſt Shootings at the Edge of the Drop are Radiations, (from a Number of very ſmall Centers,) which ſpread till they meet each other, whereby their Progreſs is for a while impeded; but other Shootings ſoon begin from the Extremities of theſe, and proceed by ſmall Steps and Renovations repreſented at *a*, *Plate* V. Theſe Figures, however, frequently diſſolve again and diſappear, and in their Places larger ones of the ſame Kind ariſe, as from their Ruins, ſomewhat in the Form of Bruſhes, *ſee b.* Small Ramifications like the Branches of ſome of the Species of Moſs ſhoot frequently from the Tops of theſe, as *c* attempts to ſhew.——But all the above mentioned Figures, which a ſmall Degree of Heat produces, ſeldom occupy more than one ſide of the Drop: the more ſolid Configurations which generally take up the other Side, not forming till near the End of the Operation. In the mean time great Part of the Middle of the Drop becomes filled with many ſmall Figures, which appearing firſt as Points, riſing under the Eye imperceptibly, ſhoot every Way afterwards

wards into very pellucid and beautiful Ramifications, as *d d*. Some Figures owing their Form to common Salt, like that ſhewn at *e*, are uſually the Fore-runners of another Kind of Configuration ariſing from the ſame Principle, which ſhoots pretty ſuddenly, and appears not much unlike the Covert Way and the Glacis or outward Slope of a fortified Place, *vid. f f.*

This Salt was bought at the ſame Place as the foregoing, and with the ſame Aſſurance of its being genuine. When kept a little while it crumbled into a white Calx or Powder, though it was at firſt in very fair Cryſtals.

CHAP. XXVI.

Epsom Salt.

A Drop of the Solution of this Salt begins to ſhoot from the Edge in jagged Figures like thoſe ſhewn at *a*, *Plate* V. From other Parts of the Edge different Configurations extend themſelves towards the Middle, ſome whereof have fine Lines proceeding from both Sides of a main Stem, in an oblique Direction, thoſe on one Side ſhooting upwards in an Angle of about 60 Degrees, and thoſe on the other downwards in the ſame Obliquity, as at *c* and *f*. Others produce Jaggs from

from their Sides nearly perpendicular to the main Stem, thereby forming Figures that reſemble the Branches of ſome Species of *Polipody:* theſe are repreſented at *e:* but in others the Jaggs are ſhorter, *vid. d.* Now and then one of the main Stems continues ſhooting to a conſiderable Length, without any Branchings from the Sides, but at laſt ſends out two Branches from its Extremity, as at *g.* Sometimes a Figure is produced having many fine and minute Lines radiating from a Center, in the Manner ſhewn at *b.* The laſt Shootings in the Middle of the Drop may be ſeen at *h,* and are not unlike the Frame Work for the flooring or roofing of an Houſe, but with the Angles a little oblique: and ſometimes a Form preſents itſelf like that ſhewn at *i.*

All theſe Figures muſt be produced with a very ſmall Degree of Heat, for if the Drop be made too hot the Salt will not ſhoot at all: but when once the Configurations are formed, the Salts fix, become ſmooth and hard like Glaſs, and may be preſerved a long time.

The Subject above deſcribed was not the true Salt of the *Epſom* Waters, which I knew not where to get; but it was I believe ſome ſort of Preparation like what is commonly ſold under the Name of *Epſom Salt,* at a very cheap Rate: though I gave a much

larger Price for this, on its being recommended as a much better purging Salt *.

Acton Salt, or what I bought for ſuch, appeared on Examination juſt like the above, but without the Figures *h i g*.

CHAP. XXVII.

SAL POLYCHRESTUM.

A Solution of this Salt when heated begins to ſhoot near the Edges of the Drop, in Ramifications, as at *a*, *Plate* V. or in

* Dr. *Quincy*, in his Engliſh Diſpenſatory, remarks what was then ſold for the Salt of *Epſom Water*, as an abominable Cheat. (*vid.* Edit. 8th pag. 355.) He informs us, "that Dr. *Grew*, having found by Experiment, that a "Gallon of Water would, on Evaporation, afford about "two Drams of Salt, endued with the Cathartic Quality of "the Water: gave an Account thereof in Latin to the *Royal* "*Society*. Upon which a certain *Chemiſt* pretending to make "large Quantities for Sale, put off a fictitious Preparation "for the true Salt of *Epſom Purging Waters*; and others "attempting the ſame Thing, the Price was ſoon brought "ſo low, that inſtead of one Shilling per Ounce, under "which the true Salt could not honeſtly be made, their fictitious Kind was ſold at not much above 30 Shillings "per Hundred Weight, which little exceeds three Pence "per Pound." And Dr. *Brownrigg* aſſures us, in his excellent Treatiſe on the *Art of making common Salt*, pag. 88. that all the Salt now vended under the Name of *Epſom Salt*, is prepared intirely from the *marine Bittern*, at the Salt Works nigh *Newcaſtle*, and at thoſe at *Lymington* and other Parts of *Hampſhire*; which Bittern is a ſaline Liquor, of a ſharp and bitter Taſte, left at the Bottom of the Salt Pans after the Salt is made and taken out. *Vid.* pag. 62.

in the Figures ſhewn at *b:* but if only a ſmall Degree of Heat be employed, it forms many very tranſparent Parallelograms, ſome having one, and ſome more of their Angles ſecanted, as at *c*.

This Salt is a mixture of Nitre and Sulphur in equal Quantities, ſet on fire in a Crucible by a Spoonful at a Time, afterwards diſſolved in warm Water, filtered and evaporated. It purges by Stool and Urine.

CHAP. XXVIII.

GLAUBER'S SALT.

AFTER the Diſtillation of *Spirit of Salt with Oil of Vitriol*, (from Oil of Vitriol, Common Salt and Spring Water in equal Quantities;) what Salt remains at the Bottom of the Retort, being diſſolved, filter'd, evaporated and cryſtalized, is called *Glauber's wonderful Salt*.

A Drop of Water ſaturated with this Salt, and gently heated over a Candle, produces Ramifications from the Side of the Drop, like the Growth of minute Plants, but extremely tranſparent and elegant, in the Manner ſhewn at *c*, *Plate* V. Some of them however begin to ſhoot from a Center at ſome Diſtance from the Edge, protrude Branches from

from that Center in a contrary Direction, and appear ſomewhat like a Bundle of Graſs or Twigs tyed together in the Middle, as at *b:* they likewiſe ſhoot ſometimes from one and ſometimes from more Sides of the central Point, in the Varieties ſhewn at *d.*

Other Figures are produced from different Parts of the Edge of the Drop, as at *a* and *f,* as alſo the parallel Shootings at *e:* but the moſt remarkable and beautiful Configuration forms itſelf laſt of all near the Middle of the Drop: it is compoſed of a Number of Lines, proceeding from one another at right Angles, with tranſparent Spaces and Diviſions running between them, appearing all together like Streets, Alleys and Squares, as repreſented at *g g.*— This Figure plainly owes its Original to Marine Salt, and is of the ſame Kind with that ſhewn at *f f,* in the *Cheltenham* Salt. The Figures *a* and *e* are vitriolic.

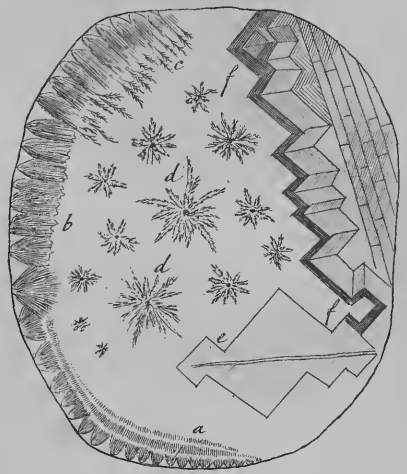
When this Configuration begins, it forms with wonderful Rapidity, affording the Obſerver a very agreeable Entertainment: but he muſt watch it carefully, for as it is produced almoſt inſtantaneouſly, its Beauty is of a very ſhort Duration: in a few Moments it diſſolves and breaks away like melted Ice, which renders the Drawing of it very difficult. The Figure in the Plate was taken at ſeveral Times and with different Drops,

in

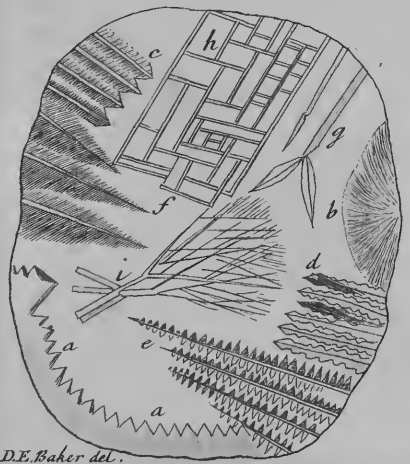
Pl.V. *p.154.* Salt of Amber.

Scarborough Salt.

Cheltenham Salt.



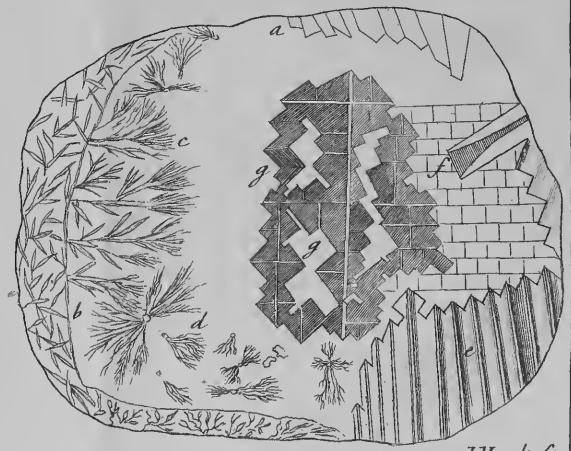
Epsom Salt.



D.E.Baker del.

Sal Polychrestum.

Glauber's Salt.



J.Mynde Sc.

in order to collect together and represent the general Idea of it.

If the Solution be not heated in the Bottle, to dissolve the Sediment it throws down, little will appear but the Brush-like Figures.

Glauber's Salt is reckoned to answer the Intention of most purging Waters: it promotes Evacuation both by Stool and Urine, and may be so made as to be less nauseous than most other artificial purging Salts.

CHAP. XXIX.

Salt of Tartar.

AFTER heating a Drop of the Solution of this Salt, there arise in many Places, near its Edges, numbers of minute Bodies, pretty irregular in their Form, but mostly inclining to be triangular; as may be seen in the Drawing, at the Side *b*. (*see Plate* VI.) Several of these appear likewise farther within the Drop, and produce all the Variety of Figures *c c*, *d d*, &c.--There shoot at the same time, from some Parts of the Edge, transparent Bodies with parallel Sides terminating as at *a*, some whereof are strewed over with the little Triangles before described. From other Parts of the Edges branched Figures present themselves, resembling small Shrubs, (*vid. f.*) whose Twigs are naked

naked at their firſt Shooting, but appear ſoon after covered with little Leaves or Tufts; the minute Bodies above mentioned which riſe near the Twigs being attracted by and adhering to them.

But the moſt odd and ſingular Circumſtance in the Shooting of this Salt is, that ſtrait Lines appear, two and two, inclining toward each other from the Edge of the Drop where they begin to ſhoot, but never meeting ſo as to form a Point, though ſometimes they extend almoſt acroſs the Drop, *vid. e.*—They may poſſibly be cylindric Tubes, but of that I am not certain.

The Humidity of the Air ſoon puts an End to all theſe Configurations.

Crude Tartar, calcined, diſſolved in warm Water, purified by Filtration, and evaporated to a Dryneſs, becomes what is uſually called Salt of Tartar: which Salt tied up in a Cloth, and hanged in a damp Place, attracts the Moiſture of the Air, and liquifies in ſuch manner, that from one Pound thereof there will drop down double its Weight of what is termed *Oil of Tartar per deliquium:* but inſtead of this the Shops frequently ſell * Pearl Aſhes liquified by the Air, which they reckon equally uſeful for the ſame Purpoſes.

Some likewiſe imagine there is no Difference in the medicinal Virtues of the Salt of

* Pearl Aſhes are a pure Sort of Pot-Aſh.

of Tartar and thoſe of Pearl Aſhes, or any other of the lixivial Salts of Plants, all which they ſuppoſe to receive alike the ſame Qualities from the Fire: but the contrary to this will I believe be manifeſt, from an Examination of the Salts I am going to ſubmit to the Reader's Judgment; the Configurations and Cryſtals whereof are ſo widely diſſimilar, that one can hardly conceive them to ariſe from exactly the ſame Principles in the Salts themſelves, or to produce exactly the ſame Effects when applied to other Bodies. 'Tis indeed probable that the eſſential Salts of Plants, collected in the Form of Cryſtals, from the Juices of their reſpective Plants, without the Help of Fire, may be different from the Salts of the ſame Plants procured by Incineration, and may have different Virtues: but I think ſuch eſſential Salts can hardly differ more from one another, when examined by the Microſcope, than the lixivious Salts of different Plants are found to do; and conſequently that theſe lixivious Salts muſt have Virtues very different from one another.

The making eſſential Salts being a troubleſome as well as tedious Operation, and conſidered only as a Matter of Curioſity, none of the Shops could afford me any of them; and even of the lixivious Salts, the Opinion of their being all alike has ſo much reduced their Number, that had it not been for the great

great Civility of Mrs. *Clutton* and Mr. *Corbin*, Chemists and Partners, in *Holborn*, (whose kind Assistance I thankfully acknowledge in this public Manner,) it would have been in my Power to procure very few of those I shall hereafter mention.

CHAP. XXX.

TARTAR *Vitriolated.*

THE rectified Oil, or rectified Spirit of Vitriol, dropt gradually into Oil of Tartar *per deliquium*, till it causes an Ebullition, produces (by evaporating the Humidity) a white Substance called *vitriolated Tartar* †.

This dissolves readily in hot Water, and a Drop of the Solution applied on a Slip of Glass before the Microscope, begins shooting round the Edge in great Numbers of very minute and transparent *Spiculæ*, detached intirely from one another, and without any of that Basis at the Edge of the Drop

† Vitriolated Tartar is commonly an Ingredient in Powders for the Teeth, as on rubbing them with it they become white immediately: but it should be used seldom and with great Caution, washing the Teeth well with several Mouthfuls of Water afterwards; for it whitens them by *Erosion*, and if frequently applyed will destroy their outward close and hard Coat of Enamel, after which the internal and more spungy Part can last but a little while.

Drop which moſt other Kinds of Salts form before they ſhoot. Theſe *Spiculæ* proceed and lengthen in different Directions, and croſs each other at various Angles, as *a a* and *b b* ſhew, *Plate* VI.

Some of theſe *Spiculæ* are very deeply ſerrated, or look rather like the Ends of bearded Darts or Arrows placed over one another, as repreſented at *c*.

A Kind of Star-like Figure will be found here and there amongſt the *Spiculæ*, apparently compounded of the above deſcribed bearded Points, and moſt commonly, like them, more opake than the other Shootings: a few of theſe appear alone, and others are formed at the Ends of the *Spiculæ*, as at *d*. Some likewiſe of the *Spiculæ*, after a while begin to ſpread, and ſhoot forwards, in an irregular Manner of branching, towards the Middle of the Drop, as at *g g*. Other Figures ariſe at a Diſtance from the Edge of the Drop, with Branches dividing and ſubdividing more regularly than the laſt deſcribed ; (*ſee* F.)

During the Proceſs, Cluſters of hexagonal Planes ariſe in the vacant Spaces, ſome regular, others with unequal Sides, ſome perfectly tranſparent, others with a ſmall Degree of Opacity, as at *e*. Theſe laſt Figures, which are indeed the proper Cryſtalizations of the united Salts, will remain intire upon the Glaſs, after all the other Con-

figurations are broken away and deſtroyed by the Air.

Among the *Spiculæ* ſhooting from the Edges there are many ſtrait-lined Figures, whoſe Ends are not pointed but flat and ſpreading; *(ſee a a.)* Theſe are chiefly owe-ing to the Tartar; and the Permanence of the hexagonal Cryſtals implies that they con-tain a large Proportion of the Vitriol.

N. B. It frequently happens, when a Drop of this Solution heated over the Can-dle, is placed under the Microſcope, the Steams ariſing from it ſo obſcure the Object-Glaſs, that nothing can be ſeen through it, until the Glaſs be clear'd with a Piece of Waſh-Leather, or a ſoft Linen Cloth.

This is the Caſe likewiſe in examining ſe-veral other Solutions, as has been before re-marked.

CHAP. XXXI.

Flowers of Benjamin.

THE Flowers of Benjamin are Salts obtained by Sublimation from a Gum of the ſame Name. Theſe Salts are ſo volatile, that on putting ſome of the Gum groſly powdered into a ſubliming Pot, they riſe with a ſmall Degree of Heat into a Cover placed over them; whence they are wiped out

out from time to time (with a Feather) in the Form of long ſlender ſhining tranſparent Bodies, and ſmell very fragrantly.

They diſſolve readily in warm Water; and a Drop of the Solution being examined by the Microſcope, will be found a very entertaining Object.--For, firſt of all there ariſe from the Edges clear colourleſs and ſharp-pointed Cryſtals (*vid. Plate* VI. *a a.*) which paſſing towards the Center, ſpread out like beautiful minute Shrubs, each having two or three Branches, like what are ſeen *b b b.* Theſe gradually enlarge and lengthen, divide and ſubdivide into ſeveral Arms and Shoots, in the Similitude of Trees (*vid. f.*) compoſing all together a Repreſentation of beautiful little Groves or Plantations. Some however continue ſhort, and ſpread into a Short of Leaves, indented ſomewhat like thoſe of Dandelion, *c c.* Little Branches likewiſe ſhoot out from Points in the Middle of the Drop, as in the Picture at *g:* and ſometimes very elegant Figures of another Kind are formed in ſome Part of the Drop, compoſed of Branches riſing (on a new Baſis) from one another, all arched alike with an equal Curvature, and having the convex Side of each Curve adorned with many little Shootings, at equal Diſtances and of equal Lengths, none of which appear on the concave Side of the Curves. All this is ſhewn at *e.*

Theſe wonderful Configurations decay immediately after the Fluid evaporates.

N. B. When a Solution of this Salt has been made ſome Days, much of it will be precipitated, and appear in Cryſtals at the Bottom of the Phial: and if you intend then to examine it by the Microſcope, 'twill be proper firſt to hold the Phial to the Fire, or place it in hot Water, till the Cryſtals become again diſſolved and taken up into the Fluid. And moſt other Solutions ſhould be treated in the ſame Manner, if they have been long made and their Salts appear precipitated: but after being thus heated they ſhould be allowed a few Minutes to ſettle, otherwiſe the Fluid will appear turbid and unpleaſant before the Glaſs, and the Configurations will not proceed ſo well.

CHAP. XXXII.

Salt of CAMOMILE.

WHEN a Solution of this Salt is examined, if much Heat be given to the Drop, the ſaline Particles will chiefly diſpoſe themſelves at the Sides thereof, in ſuch Figures as are ſhewn *a a*, *b b*; but with a leſſer Degree of Heat they will form more within the Drop, in a wonderful Variety of hexangular Planes, many of which are extremely

tremely thin, flat, and transparent, (*vid. c c*, and other Figures in the Plate.) Some however have a considerable Solidity, as the Drawing also represents. The above Figures soon dissolve and break away, and towards the End of the Process several Crystals appear with square Bases, in the Form exactly of those of Sea-salt, *vid. d*, and these are more permanent than the others were.

The Taste of this Infusion is salt at first, soon after very acrid.

CHAP. XXXIII.

Salt of CORAL.

THIS Salt begins shooting from the Sides, as at *a a*, (*Plate* VI.) and proceeds, forming Bodies some of whose Parts are opake and others transparent, of a darkish brown Colour, with Channels or Hollows running from Top to Bottom, as represented *b b*. There are likewise other of the same Figures, opake at Bottom, but transparent at their Tops, and having none of the same Channels, in the manner shewn *c c*.

In some Places of the Drop the same Kind of little Hillocks are seen, adorned with

ſurpriſing Configurations moſt exceedingly minute and delicate, bearing the Reſemblance of ſome Species of the ſmalleſt and moſt elegant Sea Moſſes. It is impoſſible to expreſs the Beauty of theſe Figures, which equal any of the fineſt *Mocha* Stones: But an Attempt to give ſome Idea of them will be found *d d d.*

After the above Appearances are compleated, and the Proceſs ſeems all over, there frequently preſents a new and unexpected Radiation of fine Lines, at equal Diſtances from each other, and ariſing as it were from a certain Point, in a very regular Order and Delineation, the Lines ſhortening gradually on either ſide, ſo as to compoſe all together a ſemicircular Figure, like that at *e.* I have found no regular Cryſtals of this Salt, nor does it uſually give any Figures at all towards the Middle of the Drop.

The Solution I made uſe of, after ſtanding in a Phial two or three Weeks, had a Cruſt over the Surface, which taken out and examined by the Microſcope, appeared to be a Congeries of minute Branches, in Shape exceedingly like ſome Kinds of Coral.

CHAP.

CHAP. XXXIV.

Salt of BAUM, *or* BAULM.

THE firſt Shootings from the Edges of the Drop, when a Solution of this Salt is examined by the Microſcope, very much reſemble Leaves, *vid. Plate* VI. *a*, on the left Side of the Picture. But theſe very ſoon enlarge and lengthen as at *a* on the Top of the Drawing; or elſe like thoſe at *a* on the right Side, which not only lengthen but ſwell at their Extremities, till they either divide into two or more Branches, after the Manner ſhewn at *d* and elſewhere in the Drop; or ſeeming to burſt or ſplit at their Tops, puſh forth Bundles of fine Hair-like Filaments, and compoſe ſuch Figures with bruſhy Heads as are repreſented at *c*: which indeed are extremely pretty. Some detached Leaves are uſually formed in the Middle, together with ſuch figur'd Cryſtals as are there ſhewn, amongſt which a few bear the Appearance of thoſe of common Salt.

When the watery Part ſeems nearly exhaled, all the forementioned Figures decay and break away, except the Cryſtals, which remain fixt: and if a full Drop has been employed, and a conſiderable Degree of

Heat applied, ſome curious Configurations preſent themſelves upon the Glaſs, conſiſting of ſhort ſtrait Lines, ſo diſpoſed as to form hexangular Figures, with delicate little Branchings therefrom, *vid. e e.*

This Salt is a very curious Subject for Examination.

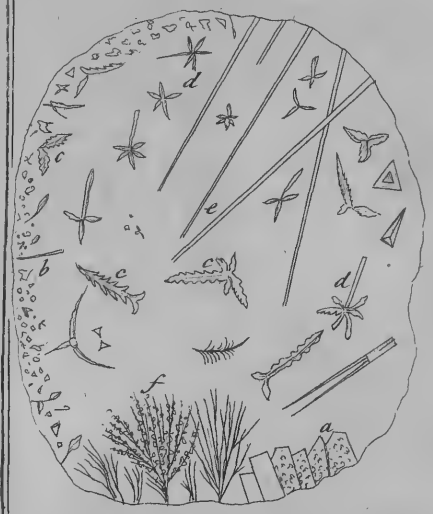
CHAP. XXXV.

Salt of FENNEL.

THE general Appearance which a Drop of the Solution of this Salt affords when examined by the Microſcope, may be ſeen *Plate* VII.

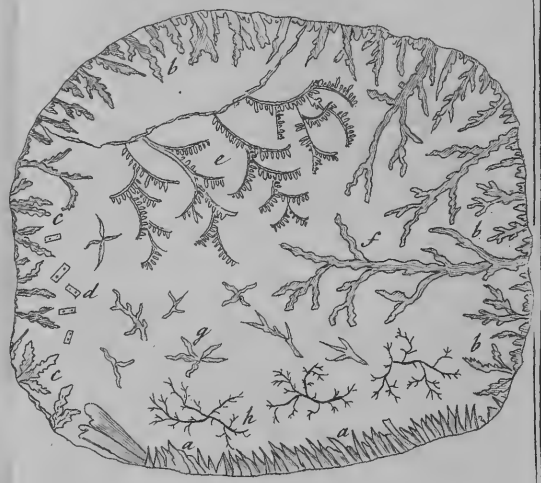
After the Drop has been gently heated, innumerable *Spiculæ* riſe about its Edges, extremely ſlender and cloſe to one another; and amongſt theſe, as well as farther within the Drop, many Bodies may be obſerved pretty regularly tapering from the Middle towards each End, ſomewhat like the Figure of a Rolling-Pin, *vid. a a.*—More in the Middle of the Drop are formed Cryſtals oddly ſhaped, ſuch as *b b*; and likewiſe others ending pointed like a Wedge. Some again are divided, as *c*; and here and there a Cryſtal of marine or common Salt is found, ſometimes in its uſual Figure, and ſome-

Salt of Tartar.

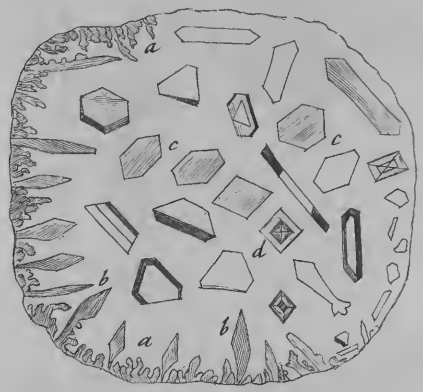


Tartar vitriolated.

Flowers of Benjamin. Pl. VI. *p. 166.*

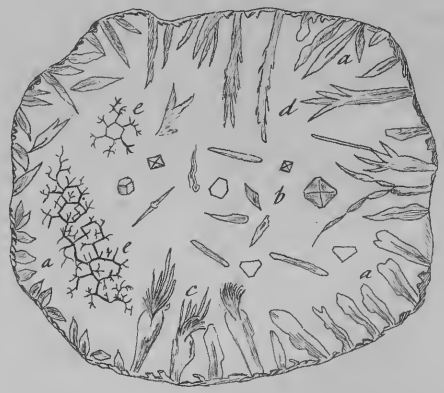


Salt of Camomile.



Salt of Coral.

Salt of Baum.



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ſometimes having an Opening at each Corner of the Baſe, as if the Angles had been artfully taken out. Theſe Differences will be underſtood by examining the Figures *d d*.

The Air puts an End to theſe Forms ſoon after they are produced.

CHAP. XXXVI.

Salt of BUCKTHORN.

THIS Salt ſhoots from the Edges of the Drop many ſharp-pointed *Spiculæ*, at little Diſtances from each other; after which the ſeveral Figures in the Drawing (*Plate* VII.) form themſelves under the Obſerver's Eye; ſome are hexangular Planes, ſomewhat opake, and appear with a conſiderable Degree of Thickneſs in proportion to their Size, as *b*; whilſt others of the ſame hexangular Planes are exceedingly tranſparent, and have no viſible Depth. Parallelograms are diſperſed here and there, and ſome Rhombi: Indeed the hexangular Figures before mentioned ſeem like Rhombi, cut off at each End. There appear a few of the Figures *c* and *d*, and alſo of the other ſeveral Forms repreſented in the Picture.

A Syrup made from the Berries of this Shrub is an uſeful Purgative in Compoſitions; but extremely nauſeous, and ſomewhat too churliſh given alone, unleſs for Perſons of very robuſt Conſtitutions.

CHAP. XXXVII.

Salt of the BERBERRY.

THE Heat neceſſary to put this Salt in Action muſt be very ſmall, but briſk; otherwiſe it will harden into a tranſparent Glue, without producing any Figures; the Reaſon of which probably is, that being of a viſcous Nature, when more Heat is given than is abſolutely neceſſary to put the Particles of the Salt in motion, the watery Parts evaporating, leave this viſcous Juice ſo ſtrong, that the Cryſtals are entangled, and cannot force their Way through it: but are prevented from acting as they do when the watery Parts remain, and the Fluid is thereby rendered leſs denſe.

The Figures it produces ſeem all to derive their Origin from *Spiculæ*, which protrude and expand themſelves in the manner to be deſcribed below. Moſt of theſe *Spiculæ* are thickeſt in the Middle, tapering to ſharp Points at each Extremity, and are very

very tranſparent; but others of them terminate more bluntly, and have their Ends opake, whilſt their middle Parts only are tranſparent, as at *a*, *Plate* VII. Sometimes theſe pointed Bodies are ſo diſpoſed as ſeemingly to iſſue from one central Point, and form ſuch a ſort of Star-like or Spur-like Figure as *b* at the Top of the Drawing; or elſe a Figure ſomewhat different, reſembling *b* in the Middle thereof.

But the moſt remarkable of all the Figures it produces are owing to the lengthening out of certain of the *Spiculæ*, whilſt they expand at the ſame time, and puſh out again other *Spiculæ* from their Sides, which likewiſe expand themſelves into very pretty tranſparent Forms, not unlike the Leaves of ſome Plants, tho' bearing no Similitude to thoſe of the *Berberry*; an Inſtance of this is ſhewn at *d*. Others of the ſame original *Spiculæ* ſhoot not ſo far towards the Middle of the Drop, but divide and expand themſelves laterally, ſpreading out into a broader Kind of Leaf-like Figures, *vid. c c c.*

Among the detached Cryſtals in the Drop there are many of a pentagonal Form, and ſomewhat more opake than the reſt, terminating at one End with an obtuſe Angle. They are not marked with any Letter in the Drawing, but will eaſily be diſtinguiſhed in looking over it. — I do not remember this Figure in any other Salt.

The

The young green Leaves of the *Berberry* Tree held in a Sieve over the Steam of boiling hot Water, rolled up between the Fingers and dryed carefully in an Oven not over hot, may eaſily be miſtaken for a good Bohea Tea; reſembling it much in Appearance, and making a Liquor extremely like it both in Taſte and Colour.—This I have myſelf experienced.

CHAP. XXXVIII.

Salt of CUCUMBER.

THE firſt Shootings of this Salt are for the moſt part Parallelipipids, radiating from a kind of indetermined Center, as at *a*, *Plate* VII. Some ſingle ones protrude themſelves forwards, widening at the Extremity, and forming Figures like thoſe at *b*. Some curvilinear Forms ſhoot alſo from the Sides, with flat Terminations, as at *c*; and others ending with ſharp Points, as *d*. A few hexagonal plane Cryſtals, as alſo ſome Shuttle-figured *Spiculæ* ariſe towards the Middle of the Drop, both which are ſhewn at *e*.

I know not any Salt whoſe Shootings are ſo extremely pellucid as thoſe we are now deſcribing: For notwithſtanding they have a con-

a conſiderable Degree of Thickneſs, they appear more tranſparent than the cleareſt Glaſs, and would almoſt evade the Sight, were it not for the faint Shadows caſt by means of that Thickneſs.

Towards the End of the Operation the empty Spaces are filled up with Shootings from ſome of the moſt detached Parallelograms, which protrude themſelves forwards, dividing and ſubdividing as at *f*, and that ſometimes to ſuch a Degree of Thinneſs and Slenderneſs as to have the Termination of their Extremities loſt to the Eye by reaſon of their exquiſite Tranſparency; this may be conceived by conſidering the Figure *g*.

CHAP. XXXIX.

Salt of PERUVIAN BARK.

THE few Shootings which this Salt produces at the Edge of the Drop are of no regular Figure, but reſemble thoſe at *a*, *Plate* VII. The whole Area of the Drop becomes quickly filled with great Numbers of Rhombi, of different Sizes, extremely thin and tranſparent, *vid. b.* Some of theſe enlarge greatly, and acquire a conſiderable Thickneſs, forming themſelves into Solids of many Sides, as *c c.* Near the Con-

Concluſion ſome Cryſtals of Sea-ſalt are formed, as *d d*; and likewiſe a few odd triangular Figures, ſuch as are delineated at *e*: Theſe and the Sea-ſalt remain, but all the other Figures break away and ſoon become deſtroyed by the Air.

CHAP. XL.

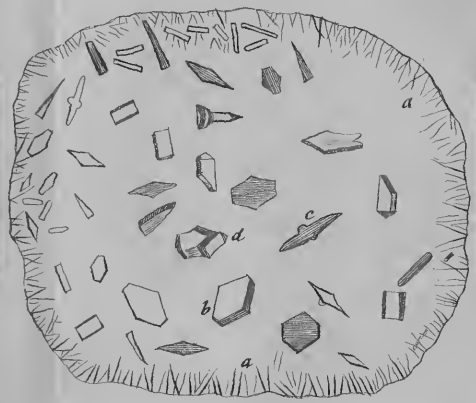
Salt of LIQUORICE

THIS Salt begins ſhooting from the Edge with a Sort of Rhombic *Spiculæ*, as at *a*, *Plate* VII. Some four-branched Figures like thoſe of the Vitriols do here ſometimes ariſe, but moulder away before their Ramifications are compleated, leaving their Stamina in the Manner repreſented *b b*. The Middle of the Drop is uſually overſpread with great Numbers of Parallelograms, ſome exceedingly tranſparent, being mere Planes; having ſometimes one, ſometimes more of the Angles canted, in ſuch ſort as to produce pentagonal, hexagonal, *&c.* Figures. Others have much Thickneſs, and form Parallelipipids, Priſms, *&c.* as at *c*. Some of the plane Figures now and then protrude an irregular kind of ſhooting, appearing very odd and pretty, *vid. d*.

Pl. VII. *p.* 172.

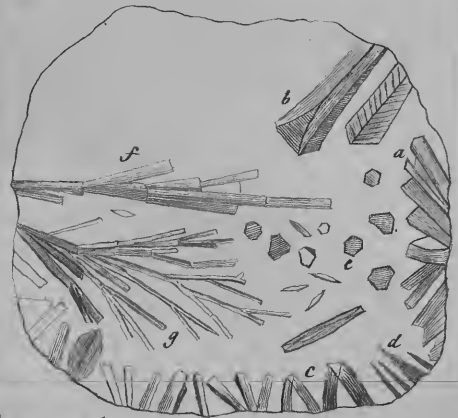
Salt of Fennel.

Salt of Buckthorn.



Salt of Berberries.

Salt of Cucumber.



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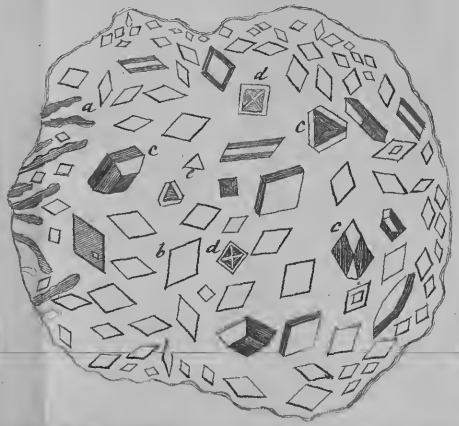
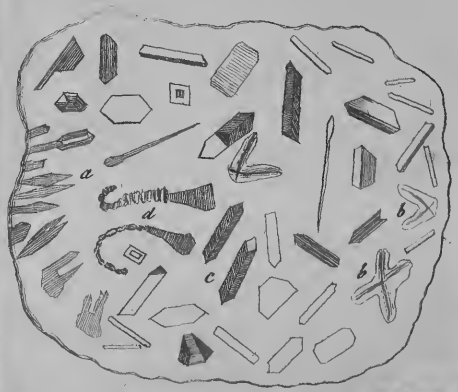
Salt of Jesuit's Bark.



Salt of Liquorice.



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CHAP. XLI.

Salt of BUTCHER'S-BROOM.

ON giving a ſmall Degree of Heat to a Solution of this Salt, Figures will be produced from the Edges of the Drop, at pretty large Diſtances from one another, running on in a ſtrait Direction, and becoming gradually larger and more clubbed at the End towards the Center of the Drop, but terminating in ſharp Points at the End that is next the Edge: which is a Singularity peculiar to this Salt.—Theſe Figures are curiouſly jagged or indented on every Side from End to End, *vid. Plate* VIII. *b b*. Some few however amongſt them ſhoot out from their Sides others of the ſame Kind, and thoſe again other ſtill ſmaller ones; but both in the primary and ſecondary Branchings the Shoots appear always on the ſame Side, as the two Configurations *d d* may ſerve to ſhew.

In the Middle Part of the Drop, and wherever there are Vacancies, two Sorts of regular Cryſtals are formed, differing each from other both in Size and Shape. The larger Kind are ſolid, and ſeem to be Tetrahedra having their uppermoſt Angle and the Edges cut off, and of theſe ſome are rectilinear and others curvilinear. Their Production is a very

very entertaining Sight: for amidſt a violent Agitation in the Fluid, numberleſs Atoms being ſeen hurried in all Directions, they riſe on a ſudden directly upwards from the Bottom, in the ſame Shape exactly as juſt now deſcribed, but ſo minute as only to be diſcernable by the firſt Magnifier, and then they increaſe in Bigneſs every Inſtant, under the Eye, till they appear as large as in the Picture; where at *c c* and in the Middle of the Drop ſeveral of them are ſhewn.—The other Sort of Cryſtals are very minute, being when viewed through the third Magnifier not larger than Carraway Seeds; they are moſtly Rhombs or Rhomboids, ſome of which have the two oppoſite acute Angles cut off; there are beſides ſome Squares and Parallelograms, *ſee a a.*

After every thing ſeems over, and all we have been mentioning begins to break away, it frequently comes to paſs, that the patient Obſerver is preſented with ſome moſt elegant Configurations, compoſed of many long Lines, perfectly ſtrait and parallel to each other; every ſecond or third whereof has at one End a ſolid Cryſtal ſhaped like the Head of a Spear or Javelin. All the Lines have alſo on one and the ſame Side Numbers of ſhort Lines, iſſuing out at right Angles, and at pretty equal Diſtances, to about half as far as the long Lines are ſeparated from one another. The long Lines in general

neral are bounded at their other End by a ſingle Line, or Baſe, that makes a right Angle to them all: a little Variation is however produced, by here and there a ſhorter Line that runs parallel to this Baſe.—The above Deſcription will be underſtood by conſidering the Configurations *e e*.

CHAP. XLII.

Salt of WORMWOOD.

THE firſt Shootings of this Salt from the Edges of the Drop appear of a conſiderable Thickneſs in proportion to their Length: their Sides are deeply and ſharply jagged or indented, being made up of many ſomewhat obtuſe Angles; and their Ends are pointed with Angles of the like Kind. What I now deſcribe are the ſingle Shoots at *a*, *Plate* VIII. But other Shoots frequently branch out from theſe original ones, and they again ſend forth others, making all together a very pretty Appearance, *vid. b b.*—Theſe laſt Configurations in their Figure and Diſpoſition bear a near Reſemblance to thoſe of *Butcher's Broom*, ſhewn at *d d:* but are larger and more deeply indented.

The Cryſtals of this Salt are very different from one another, conſiſting of Squares, Rhombi, Parallelograms, equilateral Hexagons,

gons, ſome of the Figures at *c c* in the *Butcher's Broom*, a Sort of Shuttle-like Forms, and ſeveral irregular Bodies; all of which will be beſt conceived by a View of them at *c*.

A ſmall Degree of Heat given to the Drop produces more of the Configurations, a greater Heat more of the Cryſtals, many of which are at firſt triangular, but ſoon loſe that Shape: and indeed the whole is very ſpeedily deſtroyed by the Air.—This and the Subject immediately preceding exhibit no Cryſtals of marine or common Salt.

CHAP. XLIII.

Salt of Tobacco.

IF a moderate Degree of Heat be given to a Solution of this Salt, its firſt Shootings will be from the Edges of the Drop, in ſlender tapering Figures ending with very ſharp Points, but at conſiderable Diſtances from one another, and conſequently not extremely numerous: along with theſe are likewiſe formed other Figures nearly of the ſame Kind, but intirely detached and farther within the Drop, and contrary to the former, in the Circumſtance of having their thicker Ends towards the Center of the Drop, and the ſharper pointing towards its Edge. They are compleat Figures, and reſemble Needles, or rather that Sort of Nail called a Brad,

Brad, which has its Head or larger End flat. Both these are shewn at *a*, *Plate* VIII.

When a little more Heat has been given, other *Spiculæ* are produced from the Edge, whose Ends spread on either Side and then terminate in a Point: and which have all along their Sides triangular pointed Crystals, not opposite to one another, but placed alternately, so as to represent a *Zigzag* with a Line drawn through its middle, *vid. b.*—The regular Crystals of this Salt are produced in the middle of the Drop, being either Hexagons or Rhombi, as at *c*.

When the Moisture is nearly exhaled there are sometimes seen to shoot from, or rather under the *Spiculæ*, upon the Plane of the Glass, a Representation of Leaves, very small at their first Appearance, but increasing gradually to what is shewn at *d*.—These I have seen but twice.

A violent Agitation may be discovered in the Fluid by the first Magnifier, during the whole Process, but chiefly at the Beginning, and extremely minute Crystals rising from the Bottom.

Oil of Tobacco is a strong Poison to many Animals: 'tis said a Thread wetted therewith, and drawn by a Needle through the Skin on the Back either of an Eel or Viper, will make it die immediately. This I have never tried.

CHAP. XLIV.

Salt of CARDUUS.

THE Cryſtals of this Salt (for it ſhoots out no Configurations) are of different Sizes and Figures diſperſed every where about the Drop. Thoſe near the Edges are very minute tranſparent Parallelograms, appearing in great Numbers, as *a a*, *Plate* VIII. In the Middle ariſe larger Cryſtals, ſhaped exactly like thoſe of marine Salt, *b b*. There are alſo much larger cryſtaline Bodies, formed here and there, having a conſiderable Thickneſs and Solidity, and conſiſting of Hexagonal and Rhomboidal Planes, *vid. c c*. It produces likewiſe ſome odd figured Bodies, which may be ſeen at *d d*.

CHAP. XLV.

Salt of LAVENDER.

NO Configurations are produced by this Salt and the laſt, that ſeemingly puſh from the Edges of the Drop, as in moſt of the preceding Kinds; but many regular Cryſtals are formed in every Part of it, after a moderate Degree of Heat has been given to it. Theſe Cryſtals are of various Figures,

viz. plain Rhomboids, having one or more of their Angles very much elongated, (ſo as to be ſometimes twice or thrice the Length of the Rhomboids from which they iſſue,) Rhombi, Squares, Parallelipipidons, and Hexagons with unequal Sides, or rather equilateral Triangles with their Angles cut off. In ſhort, the Figures of this Salt will much better be comprehended by applying to the Picture, *Plate* VIII. than by any Deſcription can be written.

CHAP. XLVI.

Salt of MUGWORT.

AT the Beginning many fine *Spiculæ* of different Sizes, appear at and about the Sides of the Drop, along with other ſlender Bodies ſomewhat ſwelling in the Middle, but ſharply pointed at each End, *vid. a a, Plate* VIII. Triangular ſolid Cryſtals, and various other Figures, are alſo formed here and there as repreſented in the Picture. But the moſt remarkable Part of this Subject, is a very elegant Sort of Configuration towards the Middle of the Drop, as at *b*; and likewiſe Shootings of the ſame Kind from its Edge, that reſemble the Branches of ſome Plant, riſing ſingle, with Leaves regularly

diſpoſed on both Sides of each Stem, as ſhewn by the other *b*.—In the Middle of the Drop at *c* are Figures of another Form which are very ſingular and pretty. Theſe all break away and become confuſed very ſoon after they are formed.

CHAP. XLVII.

Salt of HARTSHORN.

ON the Application of a very ſmall Degree of Heat, Salt of Hartſhorn ſhoots near the Edges of the Drop, into ſolid Figures ſomewhat reſembling Razors or Lancets where the Blade turns into the Handle by a Claſp, as at *d*, *Plate* IX. This Appearance is however wholly owing to the Junction of a ſmaller and larger Body at their ſmaller Ends, either a right or an acute Angle, as will be evident on conſidering ſome of theſe Bodies that appear ſingle.

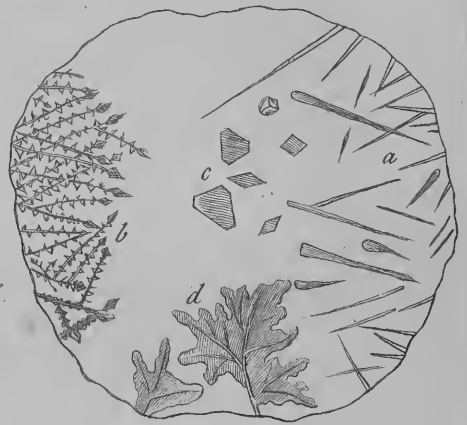
The Configurations of this Salt are produced with great Velocity, and are Figures ſomewhat opake, ſhooting from the Edges of the Drop, on both Sides a main Stem, and with a kind of Regularity, rugged Branches like thoſe of ſome Sort of Coral, *vid. a a*. But ſometimes inſtead of Branches on both Sides the main Stem, ſharp *Spiculæ*, ſome plain and others jagged, are protruded

to

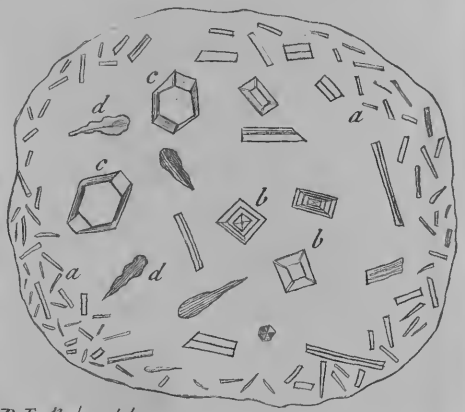
Salt of Butcher's Broom.

Salt of Wormwood.

Salt of Tobacco.



Salt of Thistle.



Salt of Lavender.

Salt of Mugwort.

D.E. Baker del.

J. Mynde sculp.

to a conſiderable depth on one Side only, as at *b*.

As the Fluid exhales, and the Attraction of the Particles becomes more ſtrong, ſome one of the branching Figures generally extends to a great Length, producing on one Side Shoots that are rugged and irregular like thoſe in the ſmaller Figures at *a a*, and on the other Side a curious regular and delicate Sort of Branches, reſembling thoſe of ſome Plant, with elegant ſmall Leaves in the Manner ſhewn at *c*.

CHAP. XLVIII.

Salt of URINE.

A Solution of this Salt ſhoots from the Edges of the Drop long Parallelograms in the Manner of Nitre; but with this Difference, that Nitre produces ſolid hexagonal Pillars, cut off obliquely at their Ends, in the Figure of a Chiſſel; whereas theſe are only plain ſuperficial Parallelograms, whoſe Ends are flat, as *a a*, *Plate* IX. But in other Places along the Sides of the Drop ſolid Angles are formed, that are ſeemingly the Rudiments of common Salt, (*vid. b.*) though neither this nor Salt of Hartſhorn afford any regular Cryſtals of common Salt.

Some of the Parallelograms increaſe much in Size, and ſpread themſelves in the Middle, ſo as to change their firſt Figure, and become three or four times bigger than the reſt: and theſe have a dividing Line that runs through their whole Length from End to End, whence iſſue other ſhort Lines, at ſmall Diſtances, oppoſite to one another, all pointing with the ſame Degree of Obliquity towards the Baſe, as may be ſeen at *c c.*

Among theſe enlarged Figures ſome few ſhoot ſtill forward and tapering towards a Point; but before they form one, ſwell again, and begin as it were a-new: and thus they proceed ſeveral times before their compleat Figure is finiſhed, which is at laſt a kind of long ſharp-pointed Body compoſed of more or fewer Joints as at *d d.*

After the whole Proceſs ſeems at an End, many ſmall Branches form themſelves on the Surface of the Glaſs, as in the preceding Salt, (*ſee* the Picture,) though their Figure is not juſt the ſame. — All the above deſcribed appear when a very moderate Degree of Heat is given, and the Drop is applied to the Microſcope as ſoon as any of the Salts cryſtalized are ſeen white about the Rim. But the Figures 1, 2, 3, 4, 5, 6, are the regular ſolid Cryſtals of this Salt, when it is let diſſolved in the Air, and no Heat at all is given.

CHAP.

CHAP. XLIX.

Salt of Millepedes, *or* Wood-Lice.

THIS Salt ſhoots from the Edges in a Manner very beautiful, and different from any other Kind yet obſerved. It begins by iſſuing from the extreme Edge of the Drop in many Lines parallel to one another, but in a very oblique Direction to the Line that borders the Drop; and other parallel Lines are produced from theſe, in an Angle ſomewhat more than right to them, the Angles of which are not ſharp but rounded, *ſee a c d, Plate* IX. Many tranſparent Parallelograms of various Length and Size are formed by theſe Lines, ſome whereof afterwards ſhoot forwards into long Spikes which ſpread at the Sides with irregular Edges, as at *d d*. In the mean while other ſhort Lines proceed outwards from the very Edge of the Drop, in a Direction quite contrary to thoſe we ſpoke of firſt, making the Border of the Drop appear very prettily ſerrated or fringed, as may be ſeen at the Bottom of the Configurations *a c d*. Another Sort of regular Figures are likewiſe produced from the Sides of the Drop, in the Manner of thoſe *b b*. When the Operation is nearly ended, there ariſe abundance of long *Spiculæ* that range themſelves ſomewhat in the Form of

Plants, filling up moſt of the vacant Places in the Drop as the Picture ſhews. This Salt has but one Sort of regular Cryſtals, which is hexagonal, and appears as at *e*.

CHAP. L.

R H E U M.

WHEN People get what they call a running Cold, it is not unuſual for a thin clear Humour to be diſcharged through the Noſtrils, in ſo conſiderable Quantity as to wet ſeveral Handkerchiefs, and even to fall from the Noſe in Drops, if not prevented by frequently wiping it away. This Humour is what I mean by *Rheum*.

Being myſelf very ſubject to this Diſorder, which is commonly preceded by a Senſation of Fulneſs and Rigidity in the Muſcles of the Head and Face, and attended with much Heat, Redneſs and Soreneſs of the Noſtrils and Parts immediately adjoining, during the Diſcharge, (which continues commonly three Days, at the End whereof it begins to thicken and become leſs acrid:) I was deſirous to know whence this limpid Humour could produce ſo much Irritation and Uneaſineſs; and as a very little Conſideration made me ſuppoſe it muſt be owing to its being loaded with pungent Salts of ſome ſort

or other, I took the firſt Opportunity of examining it by the Microſcope, and had the Pleaſure then, and many times ſince, to find my Conjecture confirmed by undeniable Demonſtration.

For this *Rheum* is ſo ſaturated with Salts, that a Drop on a Slip of Glaſs will ſoon ſhoot in a very beautiful and ſurprizing Manner, either with or without Heat: but if heated to about the Warmth of Blood, and then placed under the Eye, many lucid Spots or rather Points will be ſeen riſing, and increaſing gradually, till their Form ſhews itſelf to be quadrangular, with two tranſparent Diagonals croſſing one another, ſee *a* and *d d*, *Plate* IX. Theſe Diagonals ſhoot ſoon after far beyond the Square, protruding other Lines, at right Angles, from their Sides; (*vid. c c.*) which other Lines produce ſtill ſmaller ones from their Sides alſo, in the Order of the firſt; and thus they go on to form Configurations, whoſe Elegance of Beauty nothing but ſeeing them can give an adequate Idea of: tho' till the Reader can himſelf make the Experiment, a Repreſentation of their general Figure is ſhewn *b b*, and in other Places of the Drop: where great Numbers appear, in their ſeveral Gradations, and after their uſual Manner, filling up almoſt the whole Space.

The fine Branchings in a little while break away, but the central Squares remain like

d d.

d d.—Some Figures at their firſt Beginning riſe in the Shape of Croſſes, which Appearance is owing to the Shootings, from the Corners of the little Squares, before they are large enough to be viſible even by the deepeſt Magnifiers. The Number of main Branches in each Configuration is moſt commonly four, but ſome are found with five or more: the Branches likewiſe are ſometimes curved; but theſe two Caſes I take to be rather accidental than natural.

When a Drop of Rheum is ſet to cryſtalize without any Heat, inſtead of branched Configurations over the whole Area, as in the above Deſcription, ſuch are formed only in the Middle; but about the Edges Plant-like Figures are produced, ſhooting ſeveral Stems from one Point, and reſembling a Kind of Sea-Moſs, *vid.* E. Branchings ſomewhat of this Kind are ſhewn in Salt of Hartſhorn.

Theſe Experiments ſhew, that upon taking Cold the Humours become overcharged with Salts: how they get there, and by what Means they may be diſcharged, is a Matter well worth Enquiry; but ſuch Diſquiſitions muſt be left to the Gentlemen whoſe immediate Profeſſion it is to ſtudy the various Diſorders of the human Body and their Cure. I may however preſume to ſay, that as all Solutions of Salt become gradually weaker, and may be rendered quite inſipid by the Affuſion

Affuſion of a watry Fluid; therefore, in Caſes of this Nature, the frequent drinking of warm Gruels, Teas, and ſuch ſmall watry Liquors, muſt in like Manner gradually dilute, ſeparate and diſperſe the acrid Salts, and be probably the moſt ready Means of carrying them off either by Urine or Perſpiration.

Quere. May we ſuppoſe theſe Salts to have been abſorbed from the external Air at the Time of catching Cold *, or to have exiſted previouſly in the Body, tho' ſheathed and harmleſs till let looſe, put in Motion and rendered acrid by the retained Matter of Perſpiration: as ſeems to be the Caſe in moſt of the animal Juices when tending to Putrifaction?

* Mr. *Freke* ſays, in his *Eſſay on the Art of Healing*, where he ſpeaks of taking Cold; "tho' every one knows "that Colds proceed from receiving the Air into our Bo-"dies improperly, yet few conſider the State of the Air, "as abounding at one Time with all the means of reſtoring "Health to us and all the reſt of the Creation, and at "another as containing in it the Cauſes of Plagues, "Peſtilence and Famine, by its occaſioning Death to "Cattle, and Blights to all the Fruits of the Earth," Pag. 147, 148.

CHAP.

CHAP. LI.

Of CAMPHIRE.

CAMPHIRE is a ſort of reſinous white Subſtance, either exſuding from certain Trees in the Iſlands of *Borneo*, *Java*, *Japan*, and other Parts of the *Eaſt-Indies*, or intermixed with the woody Fibres in the Bodies and Roots of ſome Trees growing in theſe Countries.—It is not ſoluble in Water, but diſſolves readily in Spirit of Wine, from which ſaturated therewith my Experiments have been all made.

If any Heat be given it muſt be very gentle, and the Microſcope and Eye applied as ſoon as poſſible; for the Shootings form ſo quick they will otherwiſe eſcape the Sight. They radiate from a Center, either with ſix or four, rarely with five Branches, whoſe Length is nearly equal: each Branch is feather'd with fine Lines that diminiſh gradually to a Point, whereby the Figures have greatly the Appearance of Flakes of Snow; and the Points of ſome filling the Vacancies between thoſe of others, ſmall are the Spaces that are left uncovered. Some few ſingle Branches are produced about the Edges of the Drop. A pretty good Repreſentation of theſe very delicate Configurations may be ſeen in the XIth Plate.

If

If no Heat at all be applied there will be more Time to examine the Configurations; nor even then will much Patience be required, for the Camphire and Spirit of Wine are both ſo volatile, that if the Drop be ſpread thin, they will ſoon begin to form, and quickly after they vaniſh quite away.

Camphire is of great Service when by any Accident too large a Doſe of Opium has been taken.

CHAP. LII.

Of MANNA.

THIS ſweet-taſted Salt is the Concretion of a Juice iſſuing from a kind of Aſh Tree during the Heat of Summer: that from *Calabria* is accounted beſt. It eaſily diſſolves in Water made ſomewhat hot, and a Drop of the Solution is a very pretty Object for the Microſcope.

Its firſt Shootings are Radiations from Points at the very Edge of the Drop: The radiating Lines appear opake, but extremely ſlender, *vid. a a a*, *Plate* XI. Amongſt theſe ariſe many minute tranſparent Columns, whoſe Ends grow wider gradually as they extend in Length, and terminate at laſt

laſt with ſome degree of Obliquity, *b b*: All the Figures round the Edges being formed in Cluſters, and making but half a Circle, bear a near Reſemblance to Bundles of ſpun Glaſs.

Some few Figures radiating from a Center every way, and circumſcribed by an Outline, are produced within the Drop, in the manner ſhewn *d d*.

But the moſt ſurprizing and elegant Configuration is compoſed of many Cluſters of Radiations ſhooting one from another over great Part of the Drop, and making all together a Figure not unlike a certain very beautiful Sea-Plant. *Vid.* C. The regular Cryſtals may be ſeen at *e*.

The Manna I examined was, I believe, genuine; but I am told a great deal is made abroad, and ſome in *England*, by an artful Compoſition of Honey, *Glauber*'s Salt, and perhaps ſome other Ingredients. A late Writer ſuppoſes they make it abroad of Honey, Sugar, and the Juice of a Tithymal or Spurge *. It is worth obſerving, that in the

* *Chriſtoph. a Coſta* ſays, that he ſaw a *fictitious Manna* ſold at *Ormuz*, which was alſo carried into ſeveral Provinces of *Perſia*, in larger Flakes and not ſo white as the genuine; but it was cheaper, and purged violently. And he was informed of its Compoſition by a certain *Brachman*, *viz.* white Starch, ſome true Manna, Scammony, a Kind of Seed brought from *Bengal* by the Name of *Viſa*, the Powder of a Root called *Dante*, and ſome Sugar, mixed together with a little perfumed Water, and expoſed to the Sun. — —

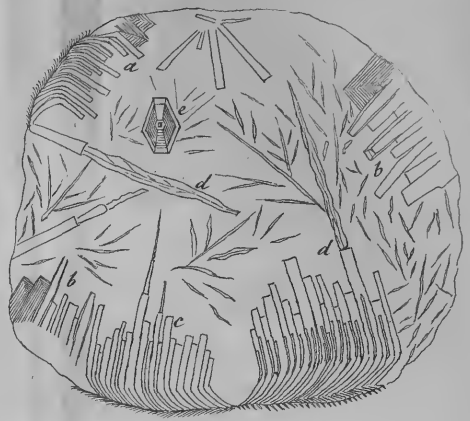
Meſue

Salt of Hartshorn.

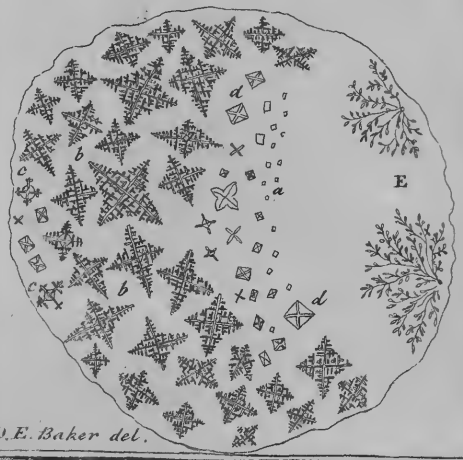
Salt of Urine.

Pl. IX *p. 190.*

Salt of Millepedes.

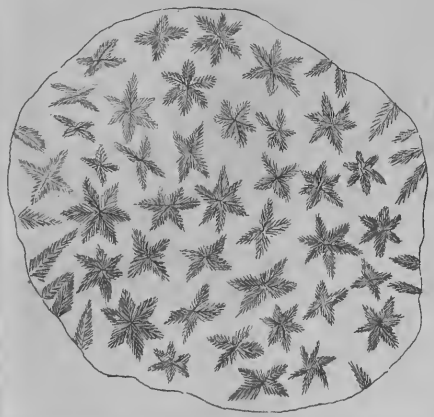


Rheum.



D. E. Baker del.

Camphire.



Manna.

J. Mynde sc.

the Midſt of the largeſt Flakes of Manna little Twigs are frequently found, not thicker than Straws, round which the Manna ſeems to adhere as Tallow does round a Wick that is dipped therein.

N. B. I ſhould here direct an Examination of *Sugar*, but could never find a way of bringing it to ſhoot or cryſtalize before the Microſcope. All other Salts after Evaporation will ſhoot their Cryſtals in a cool Place, but *Sugar* requires a hot Stove to make it cryſtalize. The Figure of its Salts *candyed* may be ſeen in *Plate* XIV. of *the Microſcope made eaſy*.

CHAP. LIII.

Concerning the Vegetation of METALS.

AFTER what has been already ſhewn and deſcribed, the conſiderate Reader will be at no great Loſs to judge of what Writers commonly call the *Vegetation of Metals*, and the *Reſuſcitation of Plants*, both which I ſhall treat of briefly.

When

Meſue likewiſe mentions the adulterating of *Manna* with Sugar and the Leaves of *Sena*: but adds, that this Fraud diſcovers itſelf by its growing ſoft and liquifying.

When any Metal is diſſolved in a Menſtruum, Multitudes of its ſeparated and very minute Particles are ſuſpended in the Menſtruum, as are likewiſe the Particles of its Salt or Vitriol. In this Mixture, when ſet to reſt, many of the ſalt or vitriolic Particles are brought together, after a while, by Precipitation and Attraction, carrying with them Particles of the Metal; and form Cryſtals, in Figures peculiar to the Metal diſſolved: *viz. Lead* produces Cubes, *Tin* quadrilateral Pyramids; *Copper* produces oblique-angled Parallelipipids, and *Iron* rhomboidal Cryſtals. This is the Caſe of one Metal diſſolved ſingly in a Menſtruum without any Mixture; and no farther Alteration happens by keeping, than that more Cryſtals will form like the firſt, or that the firſt become enlarged, by the Precipitation and Attraction of more of the vitriolic Salt: Perhaps too ſome of the metallic Particles (if is has been over-charged) will be found at the Bottom of the Fluid, though great Part of them will always remain ſuſpended.

But if different Metals or metallic Subſtances be diſſolved in the ſame Menſtruum, or in different Menſtrua, and afterwards mixed together: or if other Fluids be poured into any Solution of a Metal or Mineral, the ſuſpended metallic and vitriolic Particles, having different degrees of Attraction and Gravity, are precipitated and attracted

attracted by one another in a Variety of complicated Directions, and unite in Configurations extremely wonderful and pretty. Some Productions of this Sort have been discovered by Accident, and called the Vegetation of Metals, and many more might undoubtedly be found, were Trials made with Mixtures of different metalline Bodies and different Menstrua. I shall give a few Examples of such metallic Configurations.

Arbor Dianæ, *or, the Silver Tree.*

Dissolve an Ounce of fine Silver in four Ounces of *Aqua Fortis:* dissolve likewise in one Ounce of *Aqua Fortis* as much Quicksilver as it will bear: mix the two Solutions in a clear Glass with a Pint of Water, stop it close, and after a Day it will begin to grow.

Or, dissolve in *Aqua Fortis* of pure Silver one Dram; put to the Solution, of distill'd Vinegar and Water each one Ounce: filter, and add one Ounce and a half of Quicksilver; mix, and shake the whole some time, in a round clear Glass Vessel, stopping the Mouth close with your Finger. Standing quiet 24 Hours it will shoot into *Branches* of various Figures.

Monsr. *Homberg* tells a way of producing a *metallic Tree* much sooner, after the Preparations are got ready,—Make four Drams of fine Silver into an Amalgama

without Heat, with two Drams of Quick-ſilver: diſſolve this Amalgama in four Ounces of *Aqua Fortis*: pour the Solution into twelve *Paris* Pints (about three Gallons) of common Water, ſtir it well together and keep it in a Glaſs Veſſel well ſtop'd. To about an Ounce of this Water, in a ſmall clear Phial, put the Quantity of a ſmall Pea of the common Amalgama of Gold or Silver, which ſhould be as ſoft as Butter. Let the Phial ſtand a few Minutes, and you will ſee ſmall Threads or Filaments riſing perpendicularly from the little Bulb of Amalgama, and thruſting out from their Sides little *Branches* in form of a Tree. The Bulb of Amalgama will grow hard, and be like a Pellet of white Earth, but the little Tree will be of a bright Silver Colour.—The ſtronger the firſt Water is made, the ſooner formed and fuller of Branches will the Tree be.

Albertus Magnus is ſaid to have produced a metallic Tree before the King of *France*, while he ſat at Dinner; I ſuppoſe by ſome ſuch Method.

Arbor Martis, *or, the Iron Tree.*

Diſſolve Iron Filings in Spirit of Nitre, pour on Oil of Tartar *per deliquium*, and a ſort of Branches will be formed and adhere

to

to the Surface of the Glaſs, repreſenting Leaves and Flowers.

ARBOR VENERIS, *or, the Copper Tree.*

The ſeeming Vegetation of Silver and Iron juſt before deſcribed, I give from other Writers; but this of Copper is I believe intirely a new Diſcovery: and I can affirm, from my own Experience, that it is extremely wonderful and pretty, and made with little Trouble.

In half an Ounce of *Aqua Fortis*, let a bright Halfpenny, or ſome ſmall † Piece of clean pure Copper remain for about twelve Hours, and then take it out. Diſſolve a little *Quick-ſilver* in as ſmall a Quantity as you can of the ſame or ſtronger *Aqua Fortis*. The Solution will be white, and like Flour and Water; at which Inſtant it muſt be put into the firſt Liquor, which will immediately become of a lovely blue, and throw down ſomething of a white Sediment, but have very little Body or Conſiſtence.

† Tho' *Aqua Fortis* acts on the Filings of Copper faſter than it can on a Lump of that Metal, I have by Experience found that very ſmall Particles of Iron rubbed from the File, and mixed with the Copper Filings, do much Prejudice to the Experiment.

As Fumes ariſing from the Solutions of Metals in *Aqua Fortis*, &c. are diſagreeable and unwholeſome, 'tis adviſeable to make them in the open Air, and ſo placed that the Wind may blow the Fumes from you.

Have ready ſome *Salt Ammoniac* finely powdered, whereof put in a very little at a Time; ſtirring it about till it diſſolves, makes the Mixture of a blueiſh white, and gives it a Conſiſtence like to Starch; which Condition ſhews it fit for your Purpoſe.

File bright any ſmall Piece of Iron, (the pointed End of a Nail about an Inch in length, or a ſmall Nail of that length called a *Brad*, does as well as any thing) place it on the Middle of a Piece of clear Glaſs of two or three Inches in width: then ſtirring the Mixture with a Quill, let a Drop fall from the End of the Quill upon the Iron, and wet it therewith all over, (or dip the Iron in the Mixture, before you lay it on the Glaſs, till it appears of a Copper Colour,) add another Drop or two of the Mixture, and with your Quill ſpread it to equal Diſtances from every ſide of the Iron, an Inch or more, laying it ſo thin as to be tranſparent. Let it remain quiet in an horizontal Poſition, and in a little while you will diſcern with the naked Eye Ramifications of the pureſt Copper ſhooting from the Sides of the Iron, reſembling the moſt elegant Branchings ſeen in *Mocha Stones*, (which may perhaps be produced by Mixtures in the Earth ſomewhat a-kin to theſe) or like ſome of the moſt minute and delicate Sea-moſſes. They will grow continu-

ally

ally larger for Hours or Days, in proportion to the Extenſion of the Liquor round the Iron. For the *Copper Particles* afloat in the Fluid, being firſt of all attracted to certain Points in the Iron, and afterwards attracting one another in an orderly Succeſſion, arrange themſelves, by the Influence and Co-operation of the Salts wherewith they are now joined, in ſuch manner, as to compoſe by *juxta-poſition* a Reſemblance of the moſt regular and beautiful Vegetation. And this Attraction and Formation of new Branches ſeems to go on, until all the *Copper Particles* in the Fluid are attracted and diſpoſed by one another in the ſame wonderful Direction and Order.

Leſt I ſhould not have expreſſed myſelf with ſufficient Clearneſs to be perfectly underſtood, I have given a Drawing, taken with conſiderable Exactneſs, of one of theſe Productions, which now lies before me, and has been growing four Days: *(ſee Plate the laſt)* this will ſhew the Manner of placing the Nail, and ſpreading the Liquor round it, and likewiſe what may be expected from it. The Drawing is not magnified, but the real Size of the Object, which is large enough to be ſeen plainly by the naked Eye.

The chief Difficulty in this Experiment ariſes from the great Difference in the Strength and Manner of the *Aqua Fortis*'s being prepared at different Shops, and even at

the ſame Shop at different Times †: which is the Reaſon I could never exactly aſcertain by Weight the juſt Proportion of the *Mercury* and *Salt Ammoniac*; that depending on the Strength and Compoſition of the *Aqua Fortis*; and therefore will admit of no other Rule, than obſerving the Colour and Conſiſtence of the Mixture, which if not white enough wants *Mercury*, and if too thin wants *Salt Ammoniac*, or both. But as neither of theſe muſt be in Quantity to weaken much the Solution of Copper, 'tis adviſeable to ſtir them in by a very little at a Time. As much of the Solution of Mercury as may amount to about $\frac{1}{20}$ part of the whole, and four or five Grains of Salt Ammoniac to half an Ounce of *Aqua Fortis*, is uſually near the Mark. If right, after ſtanding a little, a thick white creamy Matter riſes to the Top, a white Sediment falls to the Bottom, and the Middle is a fine tranſparent blue Liquor. When uſed it muſt be ſtirred together, and employed before it ſeparates: and when ſpread upon the Glaſs it appears of a blueiſh white; which Ground is ſo

† Some *Aqua Fortis* I bought became in diſſolving Copper not of a blue but of a green Colour; but on putting in the Mercury it changed to a moſt lovely blue, and made the beſt Mixture I ever had; for it might be ſeen to vegetate in a Minute's Time; and produced, in a few Hours, vigorous Branches of an Inch in Length. But there is ſome Nicety requiſite in the Management of the Mercury; for the Minute it is diſſolved by the *Aqua Fortis*, even before the Fermentation is quite over, it muſt be mixed with the Solution of Copper, or elſe it will concrete into a white Subſtance like Salt, and never mix intimately with the Copper Solution.

ſo fine a Contraſt to the Colour of the Copper, that when the Branches are formed it looks like the fineſt *Mocha Stone:* and a Jeweller to whom I ſhewed one of theſe Productions told me, a Stone like that would be worth an hundred Guineas.

This Experiment ſeems of great Importance; ſerving to explain how Ramifications of a like Appearance are produced, either on the Surface or in the Fiſſures of *Slate, Flints, Agates, Mocha Stones, Florentine Marbles,* &c. and perhaps even in their very Subſtance at the Time of their Formation, by the Intermixture of ſaline and metalline Particles; and alſo how Metals, diſſolved by and incorporated with the ſaline Juices of the Earth are formed into *Branches* and *ſeem* to vegetate ‡. It was diſcovered, accidentally, by the very ingenious Mrs. *Colembine*, of the City of *Norwich*,

‡ Of this Kind I ſuppoſe the *Ramifications* of Silver, Copper, and Iron to be that are met with oftentimes in Mines; either incorporated with the Stony Bed of the Metal, as in the capillary, vegetative, or arboreſcent *Silver Ore* from *Potoſi*, or in Shootings or Branchings out from the Ores themſelves: in the Manner of an *Iron Ore* deſcribed by Doctor *Woodward*, (Vol. I. Claſs IX. Part IV. N° 85.) having very fine *Shoots* or *Efflorescencies*; from a perpendicular Fiſſure in a vaſtly high Mountain in *Cumberland*; where he ſays, great Numbers of much finer Shoots than that in his Poſſeſſion, (but ſo brittle and tender he could not preſerve them,) roſe like Vegetables, with a ſingle Stem, which parted afterwards into ſeveral Branches, of all Sizes, to the Height of near two Inches. The Stems were round, and ſo were the Branches; but towards the Extremities they were ſo jagged as to reſemble common *Heath*. They were exactly of the Complexion of Iron, a duſky red with a Caſt of blue.

wich, in her ſearch after new Colours, from Copper, for painting in Miniature. The *Scarlet Dyers* uſe in their Buſineſs *Aqua Fortis* ſaturated with Tin, and make no Secret of it; but one of that Trade, who is thought to excel in the Richneſs of his Scarlet, prepares his *Aqua Fortis* after a Manner known only to himſelf. In ſome of this Mrs. *Colembine* diſſolved Copper: and happening to leave a Piece of Iron in the Mixture, ſhe was ſurprized with the Branchings from it, and ſhewed them to my very ingenious Friend and Correſpondent Mr. *William Arderon*, F. R. S. who by her Deſire ſent an Account thereof to me, (in *June* 1751) and with it ſome of the ſame *Aqua Fortis*; whereinto I put an Halfpenny, and let it remain four or five Days according to his Directions; in which Time the *Aqua Fortis* acquired the Conſiſtence of Starch of a pale blue Colour; and on applying it to a Nail, in the Manner deſcribed already, it might, in a very few Minutes, be ſeen to ſhoot out Branches, that would continue growing five or ſix Days, according to the Extenſion of the Fluid; and in numberleſs Trials it never failed once. The Branches were evidently of a pure and finely coloured Copper, riſing above the Fluid, exactly regular, and perfectly diſtinct and ſeparate; as the Drawing, which was taken from a Production by the ſame Liquor that had been growing four Days, will ſhew.

This *Aqua Fortis*, which was very clear and

and pale, with a ſlight Teint of a pearly Colour, was ſuppoſed to be only ſaturated with *Tin:* but on trying *Tin* with other *Aqua Fortis*, and making Experiments with *Aqua Fortis* prepared by other *Scarlet Dyers*, we found ourſelves diſappointed and the Vegetation very imperfect.

Aqua Fortis bought at ſeveral Shops in *London*, corroded, or rather burnt the ſhavings of *Tin*, with great Fermentation, Heat and Violence; reducing them to a white Paſte-like Subſtance, that lay at the Bottom and left the Liquor perfectly colourleſs: and when the Copper was afterwards put in, conduced not at all towards giving the Mixture a Conſiſtence, or promoting the Branchings out; whereas the *Tin* in Mrs. *Colembine's Aqua Fortis* was kept ſuſpended, threw down no Sediment, and thickened the Mixture. But as that *Aqua Fortis* can not be got by People diſtant from *Norwich*, many Endeavours have been uſed to produce the ſame Effect by other Means: and we luckily found it might be done by the Method juſt now deſcribed. We diſcovered alſo, in making Experiments without Number on this Occaſion, that different kinds of Branchings equally ſurprizing and beautiful may be produced by different Mixtures. *Viz.*

Aqua Fortis ſaturated with Copper, and applied to a Nail, will without any Addition ſhoot forth very pretty Branches, after ſtanding quiet a few Hours, if a due Proportion

portion of *Nitre* be in the Compoſition of the *Aqua Fortis*.

A like Solution, with the Addition of *Salt Ammoniac**, will ſhoot ſooner and ſtronger.

If ſome *Nitre* and *Alum* powdered, and in equal Quantities, be put to the ſame Solution of Copper, inſtead of *Salt Ammoniac*, Branches will be produced, of quite another Faſhion and Character.

Diſſolve 7 or 8 Grains of *Tin* Shavings in half an Ounce of Spirit of *Nitre:* this will be effected without great Ebullition, and the Metal be intirely ſuſpended. Put into the Solution a clean Halfpenny, which take out after 12 Hours; then add a few Grains of *Salt Ammoniac*, putting it in by little and little, and trying the Mixture from time to time. This ſhoots very well.

Aqua Fortis ſent me from *Norwich*, (made there by Mr. *Finch*) ſhoots very well either with or without *Tin*. It diſſolves *Tin* without any Precipitation, and afterwards acquires a Conſiſtence with Copper, like that of Mrs. *Colembine*.—Five Grains of *Tin* were put into 7 Pennyweight of this *Aqua Fortis:* In leſs than an Hour an Halfpenny was put into the Solution; and two Hours after, a Nail being dipped in the Mixture, (which was then as thick as Starch) and placed upon the Glaſs with ſome more of the Mixture round it, began to vegetate in five Minutes.

An

* *Salt Ammoniac* with *Aqua Fortis* makes an *Aqua Regia*.

An Halfpenny was put into four Penny Weight of the ſame *Aqua Fortis:* four Hours after a Nail was dipped therein, and placed upon the Glaſs, and in 15 Minutes the Copper ſhot itſelf all round. *Salt Ammoniac* added to it quickens the Experiment and makes the Shootings ſtronger.

A Solution of Copper in *Aqua Regia* ſhoots out pretty Branchings of Copper, and better ſtill if ſome *Salt Ammoniac* be put to it after the Copper is taken out.

Tin will diſſolve and be ſuſpended in *Aqua Regia:* it blackens the Liquor during the Ebullition, but leaves it at laſt clear without any Precipitation.—Diſſolve 7 or 8 Grains of *Tin* in half an Ounce of *Aqua Regia,* then put in an Halfpenny, which let remain 24 Hours. This Mixture will have the Conſiſtence of Starch, and will vegetate round the Nail; it is of a dark green Colour. 'Twill be improved by a little *Salt Ammoniac.*

I could give many other Experiments of this Nature, but the *Curious* and *Ingenious* will be able from theſe Hints to make Diſcoveries themſelves of a great Variety of Branchings, by diſſolving Copper in different Menſtrua, and by adding Mercury, Tin, Nitre, Alum, blue Vitriol (which contains *Copper,*) Corroſive Sublimate, Saccharum Saturni, Borax, *&c.* This may eaſily be done, by adding which they pleaſe to a Drop or two of the *Copper Solution* upon a Plate of Glaſs, and trying it with a Nail: and if they like

like the Effect, the ſame Mixture may then be made in a large Quantity and kept in a Phial to entertain them at any time; for all theſe Mixtures may be preſerved in good Condition many Months *.

It may be proper to obſerve in general, that thoſe Mixtures are the moſt agreeable which have ſome *Body* or *Conſiſtence*; and that ſuch Conſiſtence is given by adding a Solution of Mercury to the Copper Solution, and then putting in *Sal Ammoniac*; or by diſſolving *Tin* in the Menſtruum before the Copper is put in. If the Mixture corrodes the Nail it never does well; or if it turns green round the Sides thereof, which it will do when overcharged with *Sal Ammoniac*; but deſpair not of any Nail's ſhooting till it has lain twelve Hours.

If you can procure *Aqua Fortis* that will diſſolve and ſuſpend *Tin*, (not burn it into a white Powder) the whole depends on leaving it of ſuch due Strength, that it may be able to diſſolve Copper enough, after it has diſſolved the *Tin*, and yet not be ſo ſtrong as to corrode and raiſe Bliſters on the Nail moiſtened therewith, thereby diſcolouring the Copper and ſpoiling the Experiment. On

* 'Tis beſt to keep all Mixtures with acid Spirits in a little Box by themſelves, and in Phials (holding an Ounce at leaſt) not more than half filled; for ſome of them will ferment and ſtand in need of room: they ſhould alſo have well fitted Glaſs Stopples.

On the contrary, if too much *Tin* be diſſolved in the *Aqua Fortis* it becomes whitiſh or milky, diſſolves not enough of the Copper, and is too weak for Vegetation. Diſappointments will alſo happen if Care be not taken in proportioning the Mercury and *Sal Ammoniac*, when they are employed: and yet the certain Weight and Meaſure cannot be laid down, from the great Difference in *Aqua Fortis*.

The Nail or Piece of Iron ſhould be filed bright at the Time 'tis uſed, and its Surface made ſo even that it may come cloſe to the Glaſs its whole Length. 'Tis beſt to hold the Nail in the Mixture for a Second or two, till it is of a Copper Colour, before you place it upon the Glaſs: your Shoots will thereby be made the ſtronger, as the Copper Particles floating in the ſmall Quantity you put upon the Glaſs, finding the Iron already covered, will diſpoſe themſelves more into Branches. But doing this often will impoveriſh your Mixture by drawing the Copper out of it: and therefore 'twill be right to keep ſome ſeparately for ſuch an Uſe.

The *Branchings* puſh out to the Extremity of the Drop, and then frequently turn along the Edges, ſtill dividing into ſmaller Ramifications, till at laſt they run into one another and become confuſed; or elſe a yellow Tinge drawn from the Iron diffuſes through the Fluid and renders them obſcure; but neither

of

of these happen till the Vegetation is nearly at an End, which is not till after several Hours, and in some Sorts several Days. They may however be preserved in good Condition, by preventing any farther Action of the Salts when the Shootings are advanced to their utmost Perfection, if at that Time the Nail be taken away carefully with a pair of Nippers; then soaking up the Liquor where the Nail lay with a little Brush or Rag, dip the Glass gently into Water, and hold it there a few Seconds. Hereby the Shootings are stopped, the Branches are left upon the Glass in very good Order, and if another Glass be put over them, guarded with Slips of Cork as directed *pag.* 36, they may be kept many Years. Sometimes indeed they will turn green (that is, grow rusty) but as their Forms continue, it takes but little from their Beauty.

Tho' all these Ramifications are large enough to be seen distinctly by the naked Eye, being frequently above an Inch in length, 'tis very desireable to examine them by Glasses through the different Stages of their Progress; for the Microscope discovers on some of them the Appearance of Flowers and Fruits, and shews many curious Particulars not else to be conceived. The 4th or 5th Glass are best for these Subjects, which require no great Magnifier.

Copper

Copper cannot perhaps be brought to vegetate ſo ſtrongly any way as by being diſſolved in *acid Spirits*; but having in the Courſe of my Experiments diſcovered other Means of bringing it to produce *very elegant Branchings*, tho' ſo ſmall as to require being viewed with Glaſſes, I ſhall not conceal them from the Reader.

Diſſolve as much of the *blueſt* and *cleaneſt Vitriol* in warm Water as it can poſſibly ſuſtain. Put a very little *Sal Ammoniac* in fine Powder upon the Glaſs Plate, to which add two or three Drops of the Vitriol Solution. When the *Sal Ammoniac* is diſſolved, place in the Mixture upon the Glaſs a ſmall *Brad* filed bright, wet it all over with the Liquor, and ſpread the Liquor round it, as in the foregoing Experiments: It will immediately attract the Copper in the Vitriol, and ſoon begin to ſhoot out Branches, the Form of which, as the Microſcope will ſhew, very much reſembles *Heath*.——*Sublimate* inſtead of *Sal Ammoniac* cauſes a different Kind of Shootings.——If the Copper Solution be overcharged with *Sal Ammoniac* or *Sublimate* it will not ſhoot at all, but turns yellowiſh round the Nail. A few Trials will ſettle the Proportion, which is according to the Quantity of Copper in the Vitriol. An exceeding ſmall Drop of Spirit of Wine will raiſe a Fermentation with the Vitriol,

but that being over before the Nail is applied, it makes the Shootings ſtronger.

The firſt Principle of Action in all theſe Experiments is the *Attraction* of *Copper* by *Iron*; but that only ſerves to cover the Iron with Copper Particles, in the Manner before deſcribed, *pag.* 80 and 81. The *Branchings* of every Sort are owing to the *Agency of Salts*; which Conſideration may perhaps lead to Means of producing Vegetations from other Metals.

'Tis hoped the dwelling ſo long on thoſe Experiments may be excuſed: as they are extremely pretty in themſelves, and ſeem to open a Way towards accounting for many of the moſt curious Productions in Nature.

CHAP. LIV.

Of the RESUSCITATION *of* PLANTS.

THE Chemiſts tell wonderful Things of the *Reſuſcitation* or *Reſurrection* of Plants from their Aſhes; and I make no Doubt extraordinary Configurations have been produced in very ſtrong Solutions of vegetable Salts, by the Means of Precipitation and Attraction: but I cannot help believing that Imagination has been greatly indulged, when they talk of Branches, Leaves and Flowers, *exactly reſembling* thoſe to which the Salts belong.

The

The famous Phyſician *Quercetanus* tells a ſtrange Story of a *Polonian* Doctor, who ſhewed him a dozen Glaſſes hermetically ſealed, in each of which was a different Plant, as a Roſe in one, a Tulip in another, a Clove July-Flower in a third, *&c.* When theſe Glaſſes were firſt brought to View, you ſaw nothing in them but a Heap of Aſhes at the Bottom; but on the Application of ſome gentle Heat under any of them, there preſently aroſe out of the Aſhes the Idea of the Flower and Stalks belonging to thoſe Aſhes; and it would ſhoot up and ſpread abroad to the due Height and Dimenſions of ſuch a Flower, and had the perfect Colour, Shape, Magnitude, and all the other Accidents, as if it were really the Flower. But whenever the Heat was drawn from it, as the Glaſs and the included Air and Matter cooled by Degrees, ſo would this Flower ſink down by little and little, till it would bury itſelf in its Bed of Aſhes; and thus it would do as often as a moderate Heat was applyed or withdrawn. *Kircher* is ſaid to have done the ſame Thing at *Rome*.

Dr. *Cox* gave an Account to the *Royal Society*, (*Philoſ. Tranſ.* N° 108) "that having "procured a large Quantity of *Fern Aſhes*, "from *Fern* burnt when between green and "dry, he extracted their Salt in the common "Manner with Water, and obtained ſeveral "Pounds of Salt, after evaporating the Wa-

" ter; the greateſt Part of which, being firſt " dryed, he expoſed to the Air, that it " might become an Oil *per deliquium.* " The Remainder of the *Lixivium* which " continued fluid, being filtered whilſt " warm, was of a very red Colour, deeper " than florid Blood and moſt Clarets, and " exceeding ponderous. The Colour ſhew- " ed it abounded with ſulphureous or oily " Parts, and the Weight that it was highly " ſaturated with the ſaline. This ſtrong " Solution being put in a capacious Glaſs, " in five or ſix Weeks depoſited a large " Quantity of Salt, at leaſt two Inches thick, " over the Bottom of the Veſſel. The " loweſt Part of the Salt was of a dark Co- " lour, as if ſome Dirt or Dregs were mixt " therewith, but the Surface next the Liquor " was exceeding white; and there ſprung " out of the whole Maſs of Salt, at ſmall " Diſtances from each other, about forty " Branches, which (excepting the Colour) " did moſt exactly reſemble that Kind of " *Fern* which is ſingle like *Polipody* and not " branched, ſending out ſeveral Leaves on " each ſide from one Stem. They differed " in Size, but were all alike in Figure, with- " out the leaſt Variation: only ſome emit- " ted more Leaves from the Stem than " others; which is alſo uſual in the natu- " ral *Fern.*"

Dr.

Dr. *Cox* likewiſe adds, "that mixing equal "Parts of *Sal Ammoniac* and Pot-Aſhes, the "latter of which had a very ſtrong ſul- "phureous Smell, yet ſeemed to abound "with Salt conſiderably alkalized; the Mix- "ture being put into a tall Glaſs Body, im- "mediately upon feeling the Heat a great "deal of volatile Salt was ſublimed, and in "the Glaſs Head he obſerved, to his Sur- "prize, a Foreſt in Perſpective of *Firs*, "*Pines*, *&c.* ſo admirably delineated, as not "to be excelled, if imitated, by the Pencil "of the greateſt Maſter."

Having left a ſmall Quantity of Compound Syrup of Balſam in a Phial, that was ſet by and forgot, with only a piece of Paper thruſt into the Mouth of it inſtead of a Cork; when it came to hand two or three Months after, I found all the watery Part evaporated and the Sugar cryſtalized at Bottom: and, what ſurprized me very agreeably, the ſaline Par- ticles of the Gums and Balſams, of which it was compoſed, had ſhot themſelves almoſt intirely round the inſide of the Glaſs Phial, in the moſt regular and pretty Configurations imaginable; and remained ſo for a long time afterwards.

The Activity and Volatility of Salts are wonderful, and I make no Doubt many en- tertaining Experiments might eaſily be made by Intermixtures of vegetable and other Salts, if any body who has Leiſure would

intentionally ſet about it. *Kircher* ſays, " if " you put into a wooden Tube, Tartar, " Quick-lime, Salt, and the Urine of a Wine- " Drinker, reduced into one Maſs, which " is to be hardened in the Sun and after- " wards ſet in a cold Cellar; from the above- " mentioned Maſs, by the Help of Salt- " petre, you will ſee Flowers branch out. " And ſuch is the Force of Nitre, that, if " in a Glaſs kept cloſe ſhut, you pour the " Juices of ſome nitrous Herbs on the above " Maſs, the Nitre contained within it being " pregnant with Spirit will force itſelf " through the very Pores of the Glaſs."

CHAP. LV.

Miſcellaneous Obſervations on Salts, &c.

HAVING gone through the Courſe of my Experiments on ſaline Subſtances, I propoſe from thence to form a few Reflections.

As it has been plainly ſhewn that the *Particles* of Salts, *diſſolved* and *floating* in a Menſtruum, will by Precipitation, or an Evaporation of the Fluid, be brought together, and unite in *Figures* peculiar to their reſpective Kinds, by ſome certain Law of Nature, (call we it *Attraction*, or what we pleaſe:) it ſeems reaſonable to believe, that thoſe cryſtaline, mineral, or metallic foſſil *Bodies* which have a conſtant and regular Con-

Configuration, derive their *Figures* from the Intermixture and Operation of *Salts* of some Sort or other. For that *Salts* abound every where in the Earth, either at Rest and locked up in Minerals and other Bodies; or in a State of Action, being dissolved and carried along in Water or some other Fluid, is a matter beyond dispute. The finer Particles of such Salts being dissolved *in* and rising *with* the Particles of Water *, float likewise in our Atmosphere in great Abundance, where by Heat and Cold, by a greater or lesser Degree of Rarifaction, as well as by other Accidents, they at different Times are (in the Air) brought together in greater Quantity, or become more dispersed and dissipated: whence considerable Changes and Alterations are produced, such as Freezing, Hail, Snow, Lightning, Thunder, &c. But I shall confine my Observations to the Effects that are probably owing to saline Particles within the Bowels of the Earth, or very near the Surface thereof.

Since we are acquainted with no *Dissolvents* of Metals where Salts are not principally concerned, it is reasonable to suppose, that in the Bowels of the Earth, Salts may likewise, when dissolved themselves, have a Power of dissolving metallic Substances; and afterwards, on the withdraw-

* Vitriol, Alum, and Nitre, are so volatile, when dissolved, as to force through the closest Cork, or between the Bottle and the Cork, tho' ever so closely stopped.

ing of the Fluid, of uniting with the metallic Particles, and bringing them together in certain Figures peculiar to ſuch an Admixture, and more or leſs perfect according to the reſpective Proportions of metallic, ſaline, and other Particles. Thoſe curious *Ramifications* in the arboreſcent ſilver Ore brought from *Panama*, which run through the Bed of Stone wherein it lies, may perhaps be owing to the Particles of that Metal having been diſſolved by a vitriolic Menſtruum, and carried along with it into the little Fiſſures of the Stone; where as the Water evaporated, the Silver Particles were ſhot out and diſpoſed by the vitriolic Salt, into *Ramifications* ſo nearly reſembling the Configurations of Vitriol. The Branchings of *Copper* and *Iron* (by ſome imputed to a vegetative Principle) are probably produced in a like Manner; and the Reaſon why *Gold* is ſeldom or never found thus branched, but always in little Lumps or Granulæ, may perhaps be, that the Salts which diſſolve other Metals are unable to ſeparate the Particles of Gold.

Rock Salt, (which differs little or nothing from the Salt of Springs and of the Sea,) *Vitriol* and *Alum*, (of which, and alſo of *Sulphur*, the ſaline Acid, Chemiſts tell us, is in all the ſame) *Nitre* and *Borax*, are I think the only foſſil or mineral Salts ſpoken of by Writers; for *Salt Ammoniac* can hardly be accounted ſuch. But it is impoſſible

to

to ſay what others beſides theſe the Bowels of the Earth may contain, or how infinitely they may be compounded and diverſified. I ſhall make no Difficulty to ſuppoſe the *component Particles* of Spars, Cryſtals, and precious Stones have been *ſeparated* and *floating* in ſome Fluid, and brought together in the Shapes we ſee them by certain Laws of Attraction, which in like Circumſtances are conſtant and unalterable. And as uniting in regular Order, and forming Maſſes of Figures *uniform* and *conſtant*, are the diſtinguiſhing Properties of Salts, (as the foregoing Experiments ſhew) the *component Particles* of Bodies thus formed muſt originally have been *Salts*, notwithſtanding the Bodies ſo compoſed are indiſſolveable: nor is the preſent fixt Condition of ſuch Particles, or the Hardneſs of ſuch Bodies, any concluſive Objection; for the making of Glaſs ſhews, that Salts may be rendered fixt, hard, and indiſſolveable. I therefore apprehend that all *cryſtaline Matter*, or the Particles of Matter whereof Spar, Cryſtals, and precious Stones are formed, is originally a *Salt*, according to my Meaning of the Word; and *Linnæus* is I preſume of ſome ſuch-like Opinion, ſince in his *Syſtema Naturæ* he places all precious Stones, even the *Diamond* itſelf, in his Claſſes of *Salts*.

Doctor *Woodward* likewiſe, though he ſpeaks not of this cryſtaline Matter as a Salt,

imputes it to the Properties that Salts have, when he ſays, *the ſhooting of any Metal proceeds generally, merely from Cryſtal, combining with it in the Concoction and Formation of the Maſs.* And again, *Metalline Matter, when pure and ſimple, never ſhoots into an angulated Figure, nor is indeed capable of doing that. The Bodies incorporated with Metals, and diſpoſing them to ſhoot into angulated Figures, are either Sulphur* (by which he muſt mean the *Sal Acidum* of Sulphur) *or Cryſtal.* "*Iron* concreting with Cryſtal determines it to a *rhomboidal* Figure, *Tin* to a *quadrilateral* Pyramid, *Lead* to a *cubic Form.* If Cryſtal be pure it ſhoots into a *ſix-ſided* pyramidal Figure, or into a Pyramid erected upon a Column, each with *ſix Sides* and *Angles.*" He moreover ſuppoſes, "the Baſis of all tranſparent Gems to be a *cryſtaline Matter* different in Hardneſs, and coloured by metallic Mixtures: *Lead* imparts a yellow, *Tin* † a black, *Copper* a blue or green, *Iron* a purple, an amethiſtine, and various Sorts of red. The Figures of all angular opake Foſſils are owing to the like cryſtaline Matter, but in them the metallic Matter ſo much exceeds the cryſtaline, as to render the Body opake."‡

That

† And ſometimes a yellow, as ſeveral large Grains of Tin in my Poſſeſſion prove.

‡ See *Woodward's* Foſſils, Vol. I. p. 188, and 220.

That the Shoots of Cryſtals are formed in a Fluid ſtrongly charged with cryſtaline Matter, will readily I believe be granted, and likewiſe that their Formation is nearly in the ſame Manner as the Formation of the Cryſtals of diſſolved Salts. But perhaps it may be inquired in what Time this Operation is brought about; and though that much depends on the Strength of the Solution, and the Evaporation of the watery Part of the Fluid, there muſt certainly be a *Criſis* when the Cryſtals begin to form; after which, little Time perhaps is required to bring them to Perfection: for, when the *floating Particles* come within the Sphere of each other's Attraction, they *ruſh together* and *unite*, according to their reſpective Figures, and that in a ſhort Time; as is plain in *freezing*, and in artificial Cryſtalization, which is brought about in the ſame Way.

Great Diſputes have ariſen among *Naturaliſts* concerning the Formation of *Corals* and *Corallines* *, under which Names Bodies of very different Contextures, Subſtances and Figures, are I think too indiſcriminately included; their Appearance indicating not only a Difference in Species, but even in Genus. Some inſiſt on their being in general the

* As I think it needleſs to enter into Particulars, by *Corals* and *Corallines* I intend, in general, whatſoever the Naturaliſts include under the Names of *Corallium*, *Millepora*, *Madripora*, *Corallina*, &c.

the *Work* of *little Animals*, whilſt others maintain that they are all *Sea-Plants*. There may be found perhaps of *both* theſe Kinds: but is there not a *Third*, (I mean the *ſtony Corals*) whoſe Production may be more akin to that of Minerals, and chiefly owing to the Operation of *ſaline Particles* incorporated with *ſtony Matter*?

The Rocks in the Sea on which theſe Corals are produced, are undoubtedly replete with *mineral Salts*, ſome whereof near their Surface, being diſſolved by the Sea Water, muſt conſequently *ſaturate* with their *ſaline Particles* the Water round them to a ſmall Diſtance, where blending with the * *ſtony Matter* with which Sea Water always abounds, *little Maſſes* will be conſtituted here and there and affixed to the Rocks. Such adhering Maſſes may be termed *Roots*: which Roots *attracting* the ſaline and ſtony Particles, according to certain Laws in Nature, may

* I call thoſe Corals *ſtony* which have a Hardneſs like unto Stone; and would be underſtood to mean by *ſtony Matter*, that Matter which conſtitutes the Baſis of ſuch Corals; without any critical Enquiry whether it is or is not different from that Kind of Matter whereof ſome Stones are made.

Dr. *Woodward* ſays, "the true marine Coral is indeed a "ſtony Subſtance, and of mineral Nature and Origin: the "conſtituent Matter of it is beat off from the Rocks and "Cliffs, (where the Agitation of the Sea is great) borne "thence, precipitated and affixed to Rocks, Stones, Shells, "or other Things, where the Water is more ſtill and calm. "As it is of the ſame Conſtitution, ſo it owes its Solidity "and the Coheſion of its Parts to the ſame Cauſe that Stones "and other Minerals do." *Hiſt. Foſſils, Claſs V. Vol. I. pag.* 129.

may produce *branched* or *other Figures*, and increaſe gradually by an Appoſition of Particles; becoming *thicker* near the Bottom where the ſaline Matter is more abounding, but *tapering* or *diminiſhing* towards the Extremities, where the mineral Salts muſt be fewer, in proportion to their Diſtance from the Rock whence they originally proceed. And the different Proportions of *mineral ſaline Particles*, of the *ſtony* or *other Matter* wherewith they are blended, and of *marine Salt*, which muſt have a conſiderable Share in ſuch Formations, may occaſion all the Variety we ſee. Nor does it ſeem more difficult to imagine that the *radiated*, *ſtarry*, or *cellular Figures* along the Sides of theſe Corals, or at the Extremities of their Branches, may derive their Production from *Salts incorporated with ſtony Matter*, than that the curious *Delineations* and Appearances of minute Shrubs and Moſſes on Slates, Stones *, *&c.* are owing to the *Shoots of Salts* intermixt with *mineral Particles:* and yet theſe are generally allowed to be the Work of *mineral Steams* or *Exhalations*; by which muſt, I think, be meant the fineſt Particles of

* Let me not be miſunderſtood to mean the *Impreſſions* of Plants found frequently on Slates, Iron-Stones, *&c.* for ſuch *Impreſſions* are undoubtedly owing to the very Plants themſelves, whoſe Figures they bear, having been lodged in the Matter whereof ſuch Slates or Stones are made, whilſt it was in a fluid or ſoft State; which they ſerve to prove it formerly has undoubtedly been.

of ſome Metal or Mineral incorporated with and brought into Action by a volatile penetrating Acid, which carrying them along with it into the Fiſſures at leaſt, if not into the ſolid Subſtance of ſuch Stones or Slates, there determines them to ſhoot into theſe *elegant Branchings*; after the ſame Manner, and frequently in the ſame Figures, as the *Particles* of *Mercury*, *Copper*, &c. are diſpoſed and brought together by the Salts in *Aqua Fortis*, of which an Account is before given pag. 196.

Such as believe theſe Corals to be the *Work* of *Inſects*, ground their Opinion, (againſt many ſeeming Appearances to the contrary,) on the ſole Suppoſition that each of their *ſtarry Cells* or *Hollows* is inhabited by *an Inſect*, who therefore was the Maker of it. I very readily believe *Inſects* are frequently found therein; for the Works of God are all ſubſervient to one another, ſo as to compoſe a perfect Whole; and as on the Earth moſt Kinds of Plants afford an *Habitation* for *Inſects*, it would be very ſtrange if amongſt the innumerable Animals in the great Sea, ſome Species or other were not intended to dwell in theſe little Cells. But without objecting to the *Diſproportion* between the Work and the Workmen, and that Animals ſo exquiſitely tender and delicate ſhould yet be able to bring together and faſhion ſuch large and heavy Maſſes of Stone-like Matter, ſince Nature

ture is every where wonderful; I ſhall only remark, that were all theſe Cells filled with Animals, and eſpecially the very large Cells in ſome Corals, to which the Animals muſt be ſuppoſed proportionably large, it could ſcarce have happened but that every Fiſher for Coral, or whoever had ſeen a Branch of it in the Sea, muſt likewiſe have ſeen theſe Animals. Beſides, at different Times, there have been ſome *diligent Obſervers* of Coral, whoſe Notice theſe Animals have eſcaped; which renders it probable, that tho' *ſome* Cells may be inhabited, the *Generality* of them are not. And as to forming Concluſions from the *minute Corallines*, whoſe Subſtance and Figure bear not the leaſt Reſemblance to theſe, and inſiſting that becauſe the little Veſſels or Caſes found on them are the *Neſts* and the *Works* of Inſects, therefore Inſects muſt have been the Fabricators of all the Corals; I ſay, to conclude thus, is ſomewhat over haſty and unphiloſophical †.

Though,

† The Animals ſuppoſed to have *formed* Corals, or to have *made their Neſts* upon them, are, for want of knowing their proper and diſtinguiſhing Characters, called at preſent by the general Name of *Polypes*; though perhaps their Species, Size, and Figure may be as different as the Corals themſelves are: but theſe Animals are deſcribed by all who ſpeak of them, as having Bodies ſo extremely tender that a very ſlight Touch will lacerate or diſorder them. They are alſo repreſented as *fixt* to one Spot, with little other Motion than that of *extending* their Arms or Bodies out of their Cells, or *contracting* themſelves and retiring therein at the Apprehenſion of Danger. Creatures thus circumſtanced ſeem very little capable of col-

Though, living far from the Sea, I have never been able to examine *Corallines* juſt taken from thence, I doubt not the Veracity of thoſe who ſay, that on placing them conveniently in Sea Water, they have by Glaſſes diſcovered minute *Polypes* in every one of the little Veſſels: but theſe Veſſels or Caſes are of a membranaceous Texture, tranſparent, and in moſt Particulars intirely different from the *ſtony Corals*; and even allowing them to be the Work and Neſts of Inſects, I am not yet, I muſt confeſs, intirely convinced that the whole *Coralline* is ſo too; for in many of them a tough Stem, ſeemingly of like Conſiſtence with that of other Sea-Productions acknowledged to be Plants, riſes from a Root or what appears to be ſo, and branches out in ſuch a Manner, that I believe the moſt accurate Examiner, *void of any Hypotheſis*, would declare it to be vegetable.—In ſhort, there are wonderful Mixtures in the Sea; Stones, Shells, and Plants, are

lecting and carrying a *ſtony* Matter, and *raiſing Edifices* therewith; and eſpecially in ſuch large Quantity, that comparing the *Smallneſs* of the Cells wherein theſe Creatures are ſuppoſed to dwell, with the *Bulk*, *Solidity*, and *Weight* of the Roots and Branches of many of the *Stony Corals*, the greateſt Part of it appears quite unneceſſary. This is directly contrary to the Oeconomy of Nature, *(frugal tho' ſufficient)* in the Shelly Caſes of the ſeveral Species of *Vermiculi*, in the *Tubuli marini*, the *Pipe Corals*, and the Habitations made by other ſmall Inſects; all which, like the *Honey-comb*, are framed of as little Matter as poſſible, thin, light and roomy, and appear to be what they are. I ſhall only add, againſt the Suppoſing *all Corals* to be made by Inſects, that ſome Sorts have no Cells either on their Stems or Branches.

are frequently incruſted with the ſtony Matter that gives the Subſtance to *Coral*; and I make no Doubt that Millions of minute Animals find or build them Habitations both on the *Corals* and the Sea-Plants.

But to leave a Digreſſion, which is not perhaps quite foreign to my Subject, and wherein I would not be thought to affirm any thing, but only to point out how the *ſtony Corals*, which are certainly formed by an *Appoſition* of Particles ſome how or other brought together, (having no *Fibres* or Veſſels to convey Juices for Nutrition or Increaſe, and therefore being no Vegetables) may poſſibly be produced with all their beautiful Regularity and Variety, even tho' on a ſtricter Enquiry they *ſhould not* appear to be made by Inſects ‡.

The Salts of Minerals and Vegetables floating in the Air produce a thouſand pretty Appearances, when brought together and concreted by Froſt. I have ſeen, in Winter Time,

‡ The Reader is intreated not to hurry over this Subject too haſtily, but to examine with due Attention the ſeveral Sorts of *Cryſtals*, *Spars*, &c. and he will find amongſt them *many* whoſe Shootings are as regular and uniform as thoſe of *Coral*, and their Variety perhaps as great; yet all theſe are allowed by *Naturaliſts* to derive their Subſtance and Form from *cryſtaline Matter*, combined with different Sorts or Proportions of *metallic*, *ſtony*, *earthy*, or other Subſtances. Let him particularly examine and conſider the *Ludus Helmontii*, the *ſtarry waxen Vein*, the *Ericæ-formis* or *Heath-like Spar*, the vegetative *Silver*, *Copper* and *Iron-ores*, and all the *regularly figured Cryſtals*, *Spars*, *Marcaſites* and *metallic Bodies*.

Time, formed in this Way, upon Windows, on wooden Pales, and ſometimes on the Webs of Spiders, very elegant Repreſentations in Miniature of Landſcapes, with Groves of Trees, and a ſeeming Variety of Shrubs and Herbs: but the moſt charming of this Kind I ever beheld uſed to be on the Glaſs Windows of a neceſſary Houſe in the Country, owing I ſuppoſe to the additional Intermixture of animal Salts.

Copper Plates are very expenſive, and Deſcriptions without them hardly intelligible, or I ſhould have added many curious Obſervations made on Mixtures of animal, vegetable, and mineral Salts, (ſome of which are in very few † Hands) as alſo on the Solutions of different Metals and Minerals by *acid Spirits*; but thoſe who know any thing of Chemiſtry, or will beſtow a little Time in the Study of Nature, will, I am perſuaded, in Conſequence of the Hints here given, ſuggeſt to themſelves numberleſs Experiments, which if purſued may prove both profitable and pleaſant.

In ſhort, *Salts* are the active Principles whereby Nature performs Wonders; as is ſufficiently

† Particularly the *Matron* of *Egypt*, brought thence and given me by Dr. *Pocock*; an alkaline Salt fermenting violently with Vinegar (whoſe Shootings are very ſingular) from *Sindy* in the Inland Parts of *Aſia*, given me by Sir *Hans Sloane*; the *genuine Salts* of mineral Springs in different Parts of the World; and many other *ſaline Subſtances* either in their natural State, or by human Art extracted or compounded.

sufficiently evident from that Variety of Figures they produce, by combination with one another, or when incorporated with Substances of other Kinds. But this has given occasion for some to object, that the Figures of Salts cannot be determined, since the same *Acid* dissolving different Bodies assumes different Shapes. *Spirit of Nitre*, say they, for Instance, having dissolved *Copper* shoots into hexagonal Crystals, having dissolved *Iron* into irregular Squares, and forms triangular thin Crystals after dissolving *Silver*. But waving all Dispute, which I shall ever carefully avoid, does not this seem a Proof rather of their Constancy than their Uncertanity? for the Shootings of pure Nitre examined alone are constantly the same; and are not the Crystals produced in *Spirit of Nitre* when *Copper*, *Iron*, or *Silver* has been dissolved therein, always constant to each respective Metal, though different from one another? What greater *Constancy* than this can possibly be expected? and would it not occasion much greater Uncertainty and Confusion were *mixt* and *unmixt* Substances to put on the same Forms?——It is likewise objected, that their Figures vary if they are differently prepared: And this indeed is true. But as with the same Mixtures or Management they are found to produce the same Crystals and Configurations, this Objection has no Force; unless it be to prove;

that the Figures they produce are *diſtinguiſhing* and *infallible Marks* of their different Degrees of Perfection, and that the MICROSCOPE may be of the utmoſt Service to diſcover Knavery and Impoſition.

End of PART the Firſt.

ADVERTISEMENT.

AS many of the CURIOUS, who deſire to keep *Solutions of Salts* in Readineſs for Examination, may chuſe to ſave themſelves ſome Trouble; Mr. CUFF, Optician, againſt *Serjeants-Inn Gate* in *Fleet-ſtreet*, can furniſh them with Boxes of different Sizes, neatly fitted with Phials and Slips of Glaſs for that Purpoſe. This may be an Eaſe to them, and 'tis hoped will prove of ſome Advantage to him.

EMPLOYMENT
FOR THE
MICROSCOPE:

PART II.

CONTAINING

An Account of various ANIMALCULES never before deſcribed; and of many other *Microſcopical Diſcoveries.*

WITH

OBSERVATIONS and REMARKS.

ALSO

A *Deſcription* of the *Microſcope* uſed in theſe Experiments: and of a new *Micrometer* ſerving to ſhew the comparative Size of magnified Objects.

TOGETHER

With *Inſtructions* for eaſily printing off any *Medal* or *Coin.*

INTRODUCTION.

THOUGH every Thing is *alike eaſy* to an Infinite and Almighty BEING, yet, according to human Comprehenſion, it appears extremely wonderful, that we find, almoſt without Exception, in theſe *Specks of Life* whoſe Minuteneſs renders them almoſt imperceptible to the Eye of Man, a greater Number of Members to be put in Motion, more Wheels and Pullies to be kept going, a greater Variety of Machinery, an Apparatus more complex and curious, a Plan ſeemingly of deeper Contrivance; in ſhort, more Elegance aud *Workmanſhip* (if the Term may be excuſed) in the Compoſition, more Beauty and Ornament in the Finiſhing, than are ſeen in the enormous Bulk of the Elephant, the Crocodile, and the Whale; compared with which, one would think them no leſs the Effect of a more exquiſite and ſuperior Art, than the Movements of a Watch appear to be, on Compariſon with the Wheels of a Coach or Waggon.

Theſe Truths need no Proof to ſuch as are acquainted with the MICROSCOPE, however incredible they may ſeem to others: that valuable Inſtrument will fully convince us, that *All the Works* of the CREATOR well deſerve our moſt diligent Attention; that Perfection appears every where; that Minuteneſs is no Mark of Meanneſs; and that nothing is ſo *little* or ſo *low* but that it can richly repay our Enquiries. Hereby we are likewiſe taught, that an Atom to *Omnipotence* is as a World, and a World but as an Atom; in the ſame Manner as to *Eternity* one Day is as a thouſand Years, and a thouſand Years but as one Day. Every Species of theſe Animalcules may alſo uſefully ſerve to correct our Pride, and prove how inadequate our Notions are to the real Nature of Things: by making us ſenſible how little of the larger or ſmaller Part of the *Creation* could poſſibly be made for us; who are furniſhed with Organs capable of diſcerning to a certain Degree only of the *great* or *little*, all beyond which is as much unknown, as far beyond the Reach of our Conception, as if it had never been.

An Examination of the Variety and Beauty of the *Works of Nature* muſt afford the moſt reaſonable Satisfaction to a contemplative Mind, as they ſtrongly evince the Agency and Omnipotence of the DEITY. Proofs of ſome all-powerful, wiſe and good Being

are

are indeed deducible from every thing around us, but the *extremely Great* and the *extremely Small* ſeem to furniſh the cleareſt and moſt convincing; and perhaps, if duely conſidered, the Fabrick of a *World*, and the Fabrick of a *Mite* may be found equally ſtriking and concluſive.

GLASSES diſcover to us numberleſs Kinds of living Creatures, whoſe Minuteneſs renders them abſolutely undiſcernable by our naked Eyes, and God alone knows how many thouſand Kinds there may be, ſtill gradually decreaſing in Size, which it is impoſſible for us to ſee by any Help whatever; to all theſe, however, we muſt believe, from reaſoning on what we know, that Providence has not only appointed the moſt wiſe means for Propagation, Preſervation, and Happineſs, but has moreover adorned them with Beauty equal at leaſt to any thing our Eyes have ever ſeen.

The ſmalleſt living Creatures our Inſtruments can ſhew are thoſe that inhabit the Waters: for though poſſibly Animalcules no leſs minute may fly in the Air, or creep upon the Earth, it is ſcarce poſſible to bring ſuch to our Examination; but Water being tranſparent, and confining the Creatures in it, we are able, by applying a Drop of it to our Glaſſes, to diſcover (to a certain Degree of Smallneſs) all that it contains. My Attention has been therefore applyed more particular-

ly to inſpect the Waters; in doing which I have been kindly aſſiſted by ſome ingenious Friends; and the following *Plates* and *Sheets* exhibit the *Figures* and *Deſcriptions* of ſuch of the minute Inhabitants thereof as have fallen in my Way, and ſeemed to me the moſt curious and extraordinary. And as *Names* are of the utmoſt Service to make People underſtand one another, I hope to be indulged the Liberty of giving ſuch to theſe hitherto unnoticed Animalcules, as correſpond in ſome manner to their Appearances; even though I may not always have choſen the moſt proper.

EMPLOY-

EMPLOYMENT

FOR THE

MICROSCOPE, &c.

PART II.

CHAP. I.

Of the HAIR-LIKE *Inſect.*

THE wonderful Animalcule I am going to deſcribe, was I believe firſt taken Notice of by my curious Friend Mr. *William Arderon*, of the City of *Norwich*, before ſpoken of in this Treatiſe, who kindly ſent me an Account thereof, together with many thouſands of the Creatures themſelves; which came to me alive, in a Veſſel of the ſame Water they were found in, and lived with me ſeveral Weeks: whereby I had frequent Opportunities of being convinced how carefully he had obſerved them, and likewiſe was enabled to relate many Particulars from my own Knowledge.

This

This little Animal (the Form whereof may be ſeen *Plate* XX. N° I.) is extremely ſlender, and not uncommonly one hundred and fifty times longer than broad. Its Reſemblance to an Hair has induced us to call it the *Hair-like Inſect*. The Body, or Middle Part, which is nearly ſtrait, appears in ſome compoſed of ſuch parallel Rings as the Windpipe of Land Animals conſiſt of, but ſeems in others ſcaled, or rather made up of Rings that obliquely croſs each other. This Difference may be ſeen in the two Figures F, G. Its two Ends are bent, or hooked, pretty nearly in the ſame Degree, but in a Direction contrary each to other; and, as no Eyes can be diſcerned, 'tis difficult to judge which is the Head or Tail.

Its progreſſive Motion differs from that of all Animals beſides hitherto deſcribed, for notwithſtanding the Body is compoſed of many Rings and Joints, it ſeems unable to bend at all, or move directly forwards: but when it is inclinable to change its Quarters, it can move from Right to Left, or Left to Right, and proceed at the ſame time backwards or forwards obliquely. And this it performs, by turning one End about, the Quarter of a Circle, as the Arc *a b* ſhews; then it does the ſame with the other End, and ſo alternately: whereby its Progreſſion is in a diagonal Line, or from Corner to Corner; as whoever will take the Trouble to

to ſhift the Points of a Pair of Compaſſes in that Manner may immediately be ſatisfied.

All its Motions are extremely ſlow, and require much Patience and Attention in the Obſerver. It has neither Feet, nor Fins, nor Hairs, but appears perfectly ſmooth and tranſparent, with the Head bending one Way and the Tail another, ſo as to be like a long Italian *ſ*: nor is any internal Motion, or particularly opake Part to be perceived, which may determine one to ſuppoſe it the Stomach or other of the Inteſtines.

Theſe Creatures are ſo ſmall that Millions of Millions might be contained in an Inch Square. When viewed ſingly, or ſeparated from one another, they are exceedingly tranſparent, and of a lovely green; but like all other tranſparent Bodies, when Numbers of them are brought together they become opake, and loſe their green Colour, in proportion as the Quantity increaſes, till at laſt they appear intirely black.

They were firſt diſcovered in a Ditch at *Norwich*, one End whereof communicates with the River there, and the other End with a ſecond Ditch, into which ſeveral Kennels empty themſelves from different Parts of the City. The Length of this Ditch is at leaſt an hundred Yards, and its Breadth nine: the Bottom, for more than a Foot in Depth, is covered with a blackiſh green Subſtance, in Appearance like a Mud, made up wholly

wholly of these and other Insects, intermixed with different Sediments from the Water. He assures me, he has constantly found much the greater Part of this black Matter to be really Insects: but were they only one half or a quarter Part thereof, what Numbers beyond all Conception must this Ditch contain?

It was Accident (whereto more Discoveries have perhaps been owing than to Design) that fortunately presented these Animalcules to Observation.—My Friend having got some Water from this Ditch, with Intent to examine by the Microscope other Insects he had taken Notice of therein, found before his Eyes a great Abundance of slender Hair-like Fibres, which he imagined to be the Stems or Roots of some extremely small Water Plants, from their appearing to him without any Life or Motion, tho' he wondered much at their Uniformity of Figure. Being however not satisfied with a single View, but continuing them under the Magnifier, and looking at them now and then, he perceived that many of those seeming Hairs which he had seen before separated from one another as at *d*, in N° II. were slowly drawing themselves together in Companies as at *e* in the same Number.—This gave him the first Notion of their being living Creatures, and set him upon watching them so narrowly, that he was quickly convinced,

vinced, not only of their having Life, but likewise of their being able to change their Situation, either from Right to Left, or Left to Right, backwards, or forwards, at Pleasure, in the Manner just now described.

Being thus far satisfied, he applied himself very diligently to examine the Structure, Motions, and other Properties of these minute Creatures; and found, by viewing them several times, and through different Magnifiers, that altho' they are most commonly composed of little Ringlets, whose Joynings appear like parallel transverse Lines as at F, N° I. many however were seen amongst them, in which great Numbers of minute Rings seemed to cross one another obliquely, and represented Scales, (*vid.* N° I. G.) but whether these are different Species or not must still remain a Doubt.

After putting a large Spoonful of the beforementioned black or rather dark green thick Matter into a Glass Jar, he filled it up with Water, very gently, as high as *h*, N° III. then leaving the said Matter to settle and lie quietly at the Bottom of the Vessel, its whole Appearance presently afterwards is shewn in the same Glass at *i*.

The next Day, when he came to examine what had happened amongst these Myriads of little Animals, he found that a Multitude of them had, as it were by Agreement, placed themselves on the Side of the Jar, and appeared

peared marching upwards in Rows, after the Manner repreſented N° IV. *l.* and that ſome of them had travelled to the Diſtance of three or four Inches, which conſidering the Slowneſs of their Motion, and their Method of moving forwards, muſt be looked upon as a long Journey.

In about two Days great Numbers had travelled up the ſide of the Jar, to above the Surface of the Water, as at *k* N° IV: when after being expoſed to the Air for a little while, their fine green colour became changed into a moſt beautiful Sky-blue.

This fine dark green Matter or Congeries of Animalcules, is ſo nearly equal to the ſpecific Gravity of Water, that at firſt putting in, it either floats at Top, or continues at the Bottom, or in the Middle of the Jar, juſt as Accident has diſpoſed it. But if Part of thoſe that are ſwimming at the Top of the Water have an Inclination to go downwards, they form themſelves into a Sort of Line or Rope, which deſcends extremely ſlow, till they arrive as low as they intend: And they are able to ſuſpend themſelves in the Water where they pleaſe, and as long as they have a mind. Their Method of doing this is ſhewn N° V. *c c c.* Thoſe however who happen to be near the Side of the Jar move themſelves down thereon, and that commonly in a winding ſcrew-like Manner, as *n n* N° V. is intended to repreſent.--Their Motion

Motion upwards in the like Order has been described already, N° IV. *l.*

A small Quantity of this Matter having one Day been put into a Jar of Water, it so happened that one Part thereof went down immediately to the Bottom, whilst the other Part continued floating upon the Top. All Things remained a good while in this Condition, until at last each of these Swarms of Animalcules grew weary of its Situation, and had a Mind to change its Quarters. Both Armies, in short, began their March at the same Time, against the Side of the Jar; and as one proceeded upwards, and the other downwards, after some Hours, they were near meeting about the Mid-Way; as the Rout each of them appeared to take, soon after they began to move, made it very easy to foresee they would. The Desire of knowing in what Manner they would behave on this Occasion, engaged the Observer to watch them with a careful Eye, and as they approached still nearer, he beheld, to his great Surprize, the Army that was marching upwards, open to the Right and Left, and leave a convenient Space for the Army that was marching downwards to pass between its Wings. Thus without Confusion or Intermixture each held on its Way: the Army that was going upwards marching in two Columns to the Top, and the other proceeding with great Regularity and Order in

one

one Column to the Bottom. N° VI. is a Representation of this amusing Accident, which serves to shew, that however mean or contemptible these Creatures may appear to us, the Power that created them has not left them destitute of Sagacity, to associate together, and act unanimously for the Benefit of the Community; both these Armies marching as regularly as if under the Direction of wise Leaders.

When these Animalcules are taken from the Ditch, and any other Water poured upon them, it is difficult to make them live twenty-four Hours; but when kept in some of the same Ditch-Water, they may be preserved in good Condition for several Months. Though they never are so vigorous, nor shew their Way of moving from Place to Place so plainly, as when newly taken up.—Their Kind of Motion, as before described, makes it evident, that if they move along the Side of a cylindrical Glass Jar, either upwards or downwards, it must be in a Spiral Line; and such it is always found to be.

It is not yet discovered whether their Food be Insects excessively minute, or Particles of Matter floating in the Water; neither do we know any thing concerning the Manner of their being propagated. They have as yet been taken notice of only in this Ditch, but 'tis reasonable to believe that other Places of

the like Kind, will, upon Examination, be found to produce them alſo, and even in great Abundance.

CHAP. II.

Of the OAT-ANIMAL.

IN the ſame Ditch-water from *Norwich* came likewiſe great Numbers of the little Creatures, whoſe ſeveral Appearances, when examined by the Microſcope, are ſhewn *Plate* X. N° vii.

My curious Friend pointed it out to my Obſervation by the Name of the *Oat-Animal*; and as, at firſt View, it much reſembles a Grain of that Sort, I ſhall here deſcribe it under the ſame Name.

This Creature is ſo very ſmall, that no true Judgment can be made of it, unleſs it be looked at through the greateſt Magnifier, nor even then without conſiderable Attention. I commonly found two or three of them in a Drop of the Sediment, amongſt Multitudes of the *Hair-like Inſect*, lying at the Bottom of the Water wherewith the ſaid Sediment was diluted, upon the Plate of Glaſs, without any viſible Motion or Appearance of Life: being incloſed in a Bivalve-ſhell, which the Animal can open or ſhut as it is inclined; but which it

conſtantly ſhuts upon being diſturbed, nor opens again until after having been quiet for ſome Time. Its Appearance when ſhut is pictured at *fig.* 1.

The Shell is ſo exquiſitely thin, and conſequently ſo very tranſparent, as to be traced out, when ſhut, only by a faint Line on the Back, where the *Cardo* or *Hinge* makes ſome additional Thickneſs; but when open, the Edges of both its Sides may be diſtinguiſhed plainly. The two Ends of the Shell can open, whilſt the middle Part remains cloſed, and in that Condition it is like the *Pholas* and ſome Species of the *Chama*; but differs from them, in being able to ſhut both Ends and alter the Figure of its Shell, which they cannot do. This probably is performed by means of certain Articulations in the Shell, near its Extremities, which are too fine to be diſcerned. When theſe Ends are open, the Creature frequently thruſts out, at each, a cylindrical fleſhy Part, (as at *fig.* 2.) which may be ſuppoſed the Head and Tail; but their Minuteneſs renders it hardly poſſible to diſcover any Difference between them. In this Poſture it is probable the Creature feeds, on that Proviſion the Water brings; though it depends not wholly on ſuch Accident, for it can change its Place by Jerks, or Leaps, which it makes by the Action of ſome ſtrong Muſcles in the two protruded

Parts, whoſe Spring throws it to the Diſtance at leaſt of its own Shell's Length every Time they are exerted. Theſe Leaps however have long Intervals between, and are never made till the Animal is perfectly undiſturbed.

Both the Shell and Body are uſually ſo tranſparent, that when the Shell is cloſed nothing can be perceived but a Sort of Shade within it: but, now and then, I have ſeen the Body, plainly, through the Shell, in Shape as at *fig.* 3.

Several of them have a Couple of very dark round Spots, one whereof is ſeemingly placed within each Side the Shell, as in *fig.* 4. Theſe I imagined to be compact Ligaments, ſerving to open and ſhut the Shell, and correſpondent to thoſe that Oyſters, Muſcles, Scallops, *&c.* are furniſhed with for the like Purpoſe. But when I obſerved others of them, having three, four, or five of the ſame round Spots, I began to think myſelf miſtaken; and ſhould rather ſuppoſe them concreted Bodies, ſimilar to the Pearls bred in ſeveral kinds of Shell-fiſh, did not the Regularity of their Poſition render this likewiſe a little improbable.

One, having five Spots, with its Shell gaping the whole Length, and both Ends thereof fully extended in a ſtrait Line, very different from what precede, is ex-

hibited *fig.* 5. — In this Condition, which is not uncommon, it much reſembles a Grain of Oats.

I muſt not omit to mention another Variety amongſt theſe Creatures, which the *fig.* 6, 7, and 8, are intended to explain. Here we ſee a Couple of tranſverſe Lines, forming a kind of Zone acroſs the middle Part of the Shell, and ſeeming to ſeparate the two Ends thereof.

Fig. 6 and 8 have the two round opake Spots before deſcribed.

Fig. 6 and 7 ſhew the Cardo of the Shell, but the ſame is not ſeen in *fig.* 8.

'Tis difficult to determine whether theſe are another Species, or only ſome of the ſame Sort of Animals in a different State or Condition. I much ſuſpect they may be about caſting their Shells, or perhaps diſtempered, or even dead; for I have never ſeen any of them open their Shells, or make the leaſt Motion, though I have ſometimes kept my Eye over them for above a Quarter of an Hour.

CHAP. III.

EELS *in Paſte* viviparous.

THE *Anguillæ*, or little *Eel-like Animalcules*, which are frequently ſo numerous in *ſour Paſte* that the whole Surface of

of it appears alive, and are ſeemingly of the ſame Kind with thoſe ſometimes found in Vinegar, were ſome of the firſt minute Creatures the Microſcope was made uſe of to examine, and are ſtill the moſt common living Objects it is employed about; I ſhould not therefore, after their having been ſo long known, and ſo often deſcribed, have introduced them here, had not a very pretty Diſcovery made a few Years ago, by Mr. *James Sherwood*, an ingenious young Surgeon, rendered them the Subject of a curious and entertaining Experiment.

Separating one of theſe ſmall Eels from a Number of others, in order to examine it by the Microſcope, and wounding it accidentally in the Belly, he took Notice that a long ſlender Tube, doubled like an Inteſtine, proceeded from the Wound: of which informing Mr. *Needham*, it excited their Curioſity to cut in two another Eel, near its Middle: when they diſcovered a Number of *living young ones*, each incloſed in its proper Membrane, iſſuing from what now plainly ſhewed itſelf to be the *Uterus*. This induced him to make farther Trials, and finding uſually the ſame Appearance, he thought proper to communicate his Obſervations to his Friends, and afterwards to the Royal Society *.

* Philoſ. Tranſ. N° 478.

I firſt ſaw the Experiment with Mr. *Sherwood*, and having ſince made it abundance of Times myſelf, am qualified to direct thoſe who may deſire to be ſatisfied, how to perform it themſelves, without any great Difficulty. — Having taken up a very ſmall Quantity of the *Paſte* where theſe Eels abound, on the Point of a Pin, or with a ſharpened Quill, lay it on a Slip of Glaſs; and diluting it well with Water, many of them will become viſible to the naked Eye: then with the nib of a Pen cut to a very fine Point, and ſhaved ſo thin as to be extremely pliable, ſingle out one of the largeſt Eels, and inſinuating the Point of the Pen underneath it, remove it into a very ſmall Drop of Water, which you muſt have ready prepared on another Slip of Glaſs. When thus confined, it may eaſily be cut aſunder, tranſverſely, by the Help of a good Eye and ſteady Hand, with a Lancet or ſharp Penknife; or if the Eye is deficient, a Hand-Magnifier will enable almoſt any Body to perform the Operation. As ſoon as the Parts are ſeparated, apply your Object to the Microſcope, and if the Diviſion has been made about the Middle of the Animal, ſeveral oval Bodies of different Sizes will be ſeen to iſſue forth. Theſe are young *Anguillæ*, of different Degrees of Maturity, each whereof is coiled up and included

included in its proper Membrane, which is of ſo exquiſite a Fineneſs as to be ſcarce diſcernable by the greateſt Magnifier, while it incloſes the Embrio Animal. The largeſt and moſt forward break immediately through this delicate Integument, unfold themſelves, and wriggle about in the Water nimbly: others get out, uncoil, and move about more ſlowly; and the leaſt mature continue intirely without Motion. The *Uterus*, or Veſſel that contains all theſe oval Bodies, is compoſed of many Annulæ or Ringlets, not unlike the *Aſpera Arteria* of Land Animals, and it ſeems to be conſiderably elaſtic; for as ſoon as the Operation is performed, the oval Bodies are thruſt out with ſome Degree of Violence by the ſpringing back or Action of this Bowel. An hundred and upwards of the young ones have been ſeen to iſſue from one ſingle Eel, whereby the prodigious Increaſe of them may be accounted for; as probably ſeveral ſuch numerous Generations are produced in a ſhort Time. Hereby we alſo learn that theſe Creatures are not only like Eels in Shape, but are likewiſe viviparous as Eels are generally ſuppoſed to be.

I ſcarce know a more entertaining Experiment; and you'll very ſeldom be diſappointed, for they ſeem like *Earth-worms* to be all prolific, and unleſs by Accident

you cut one that has brought forth all its Young before, or make your Trials when the Paſte has been kept a very long Time, (in which Caſe I have found them ſometimes unfruitful,) you'll not fail of being diverted after the Manner above deſcribed.

One of the *Anguillæ*, greatly magnified, and through the Body of which, before cutting, faint Traces of the young ones may be diſcerned, is ſhewn, N° VIII. *Plate* X.

The ſame, after being cut, with young ones iſſuing from it, and the *Uterus* as it uſually appears, is repreſented in a Drop of Water, N° IX.

This Diſcovery is of more Conſequence than without due Conſideration it may ſeem to be; for as theſe Animalcules are plainly viviparous, and bring forth *living* and *perfect young ones* in their Eel-like Form, it is highly improbable that they ever become Flies, or undergo any other Change; ſince no Animal has been yet known to put on a new Shape after it has produced its Young, whether in the Egg or otherwiſe. Therefore if theſe *Anguillæ* never change to Flies, or lay Eggs, which this Experiment renders it very unlikely they ſhould ever do, they can neither convey themſelves to any Diſtance from the *Paſte* wherein they firſt appear, nor be propagated by Eggs floating in the Air. The

Queſtion

Queſtion then will be, by what Means they get into the *Paſte* at all: for ſuppoſing it poſſible they might have been in the Wheat, and have eſcaped unhurt through the ſeveral Operations of grinding the Corn, ſifting it, *&c.* it is ſcarcely credible (in whatever Condition they might remain in the Flour) that they ſhould be able to endure boiling, without which, and that too for a conſiderable Time, no good *Paſte* can be made.

For my own Part, I muſt acknowledge, that before this Diſcovery I was ſtrongly of Opinion that theſe Eels change into Flies; as many Kinds of Worms found in Waters are well known to do, and in that State depoſit their Eggs in whatever Places they find a proper Neſt and Proviſion for their future Offſpring; and this my Opinion I thought confirmed, by ſometimes obſerving very minute Flies, of a Size agreeable to ſuch a Suppoſition, hovering about the Glaſſes where *Paſte* with Eels was kept. But as bringing forth living young ones, in their Eel-like State, is a Fact beyond all Doubt, I muſt believe the Flies I ſaw about the *Paſte* are Inſects of ſome other Kind, and have no Relation to theſe Eels; unleſs we could imagine them to have a two-fold Method of Generation; that is, to be both viviparous and oviparous, and to propagate both in the Eel and in the

the Fly State; which is too extraordinary a Particularity to be admitted without the ſtrongeſt Proof *.

Theſe Difficulties muſt be left to future Enquiry; and I hope the *Curious* will endeavour to ſolve them by careful Experiments and Obſervations.

CHAP. IV.

EELS *in blighted Wheat.*

THE Diſcovery of a certain Kind of *Anguillæ*, or Animalcules reſembling *Eels*, in blighted Wheat, was made accidentally by my very ingenous Friend Mr. *Turberville Needham*, in the Summer of the Year 1743, in the Manner deſcribed by himſelf in his curious Book of *New Microſcopical Diſcoveries* †.

Theſe Animalcules are not uſually lodged in ſuch blighted Grains of Wheat as are covered externally with a Soot-like Duſt, (whoſe

* *Mentzelius* publiſhed Obſervations made on the Proceſs of the Transformation of *Eels in Vinegar*, which, he tells the World, he ſaw iſſue in *Flies*; which Flies did afterwards lay their *Eggs* in the Vinegar, *&c.* And he has given Drawings of the ſaid Flies with his own Hands. On the contrary, *D. Marcus Antonius Cellius* affirmed to the Phyſico-mathematical Society at *Rome*, Anno 1688, that with very good Microſcopes of his own making he found the *Eels in Vinegar* to be *viviparous*.

† Vid. *New Microſcopical Diſcoveries* by Mr. *Needham*, pag. 85.

(whoſe Inſide is likewiſe frequently converted into a black Powder :) but abundance of Ears may be obſerved in ſome Fields of Corn, having Grains that appear blackiſh, as if ſcorched; and ſuch when opened are found to contain a *ſoft white Subſtance*, that attentively examined ſeems to be nothing elſe but a Congeries of Threads, or Fibres, lying as cloſe as poſſible to each other in a parallel Direction, and much reſembling the unripe Down of ſome Thiſtles, on cutting open the Flower-Heads before they begin to blow. This fibrous Matter diſcovers not the leaſt Sign of Life or Motion unleſs Water be applied to it; but immediately on wetting, (provided the Grains of Wheat are newly gathered) the ſuppoſed Fibres ſeparate, and prove themſelves to be living Creatures, by Motions that at firſt are very languid, but gradually become more vigorous, twiſting or wriggling themſelves ſomewhat in the Manner of the Eels in Paſte, but always much ſlower than they, and with a great deal leſs Regularity; for in them the Head and Tail are conſtantly moving, contrarywiſe, and alternately, with the ſame Kind of bending or Undulation in the Bodies of them all; whereas the Animalcules we are now deſcribing have no Uniformity in their Motion, but bend their two Extremities ſometimes differently and ſometimes in the ſame Direction.

If

If the Grains of Wheat are grown dry by keeping, and you cut them open in that Condition, the fibrous Matter is very diſtinguiſhable, and on putting Water to it will ſeparate with great Readineſs, and ſeem like fine Tubes or Threads tapering at both Ends: but not the leaſt Motion or Symptom of Life will be perceived till they have been in Water for ſeveral Hours; nay, frequently they will never revive or come to move at all. But if the ſame Grains be ſteeped in Water for ſome Hours, or buried for three or four Days in Earth, till they are fully ſaturated with Moiſture, and then opened with a Penknife, on taking out a ſmall Portion of the *White Matter* carefully, and ſpreading it thin upon a Slip of Glaſs, the Animalcules may be ſeen bundled together, and extended longitudinally, but without Motion; and though upon the Application of Water, they will not revive ſo ſoon as thoſe taken from freſh Grains, whoſe Moiſture has never been exhaled; yet, after abiding an Hour or two in Water, I have conſtantly found them alive and vigorous; and that, notwithſtanding the Grains have been kept in a dry Condition even for ſome Years; of which I have a remarkable Inſtance now before me.

In the Month of *Auguſt* 1743, a ſmall Parcel of *blighted Wheat* was ſent by Mr. *Needham* to *Martin Folkes*, Eſq; Preſident of the

the *Royal Society*, (with an Account of his then new Diſcovery:) which Parcel the Preſident was pleaſed to give me, deſiring I would examine it carefully. In order ſo to do, I cut open ſome of the Grains that were become dry, took out the fibrous Matter, and applied Water to it on a Slip of Glaſs; but could diſcern no other Motion than a Separation of the Fibres or Threads; which Separation I imputed wholly to an Elaſticity in the Fibres; and perceiving no Token of Life, after watching them with due Care, and repeating the Experiment till I was weary, an Account thereof was written to Mr. *Needham*; who having by Trials of his own found out the Cauſe of this bad Succeſs, adviſed me to ſteep the Grains before I ſhould attempt to open them; on doing which I was very ſoon convinced of his Veracity, and entertained with the pleaſing Sight of this wonderful Phænomenon. Since then I have made Experiments at different Times with Grains of the ſame Parcel, without being diſappointed ſo much as once, and particularly on the fourth Day of *July* 1747, finding ſome of the ſame Parcel left, I ſoaked a Couple of Grains in Water for the Space of thirty-ſix Hours, when believing them ſufficiently moiſtened, I cut one open, and applying ſome of the fibrous Subſtance to the Microſcope in a Drop of Water, it ſeparated immediately, and preſented

ſented to my View Multitudes of the *Anguillæ*, lying as repreſented N° X, B, without the leaſt Motion or Sign of Life. But Experience having taught me by former Trials, that they might notwithſtanding poſſibly revive, I left them for about four Hours, and then examining them again, found much the greateſt Number moving their Extremities pretty briſkly, and in an Hour or two after, they appeared as lively as theſe Creatures uſually are. Mr. *Folkes* and ſome other Friends were Witneſſes of this Experiment.

We find an Inſtance here, that *Life* may be ſuſpended and ſeemingly deſtroyed; that by an Exhalation of the Fluids neceſſary to a living Animal, the Circulations may ceaſe, all the Organs and Veſſels of the Body may be ſhrunk up, dried, and hardened; and yet, after a long while, *Life* may begin a-new to actuate the ſame Body; and all the animal Motions and Faculties may be reſtored, merely by repleniſhing the Organs and Veſſels with a freſh Supply of Fluid. Here is, I ſay, a Proof, that the Animalcules in the Grains of blighted Wheat can endure having their Bodies quite dried up for the Space of four Years together, without being thereby deprived of their *living Power:* and ſince, after they are become thus perfectly dry and hard, there ſeems little room for farther Alteration, unleſs their Organs ſhould

be

be broken or torn asunder; may they not possibly be restored to Life again, by the same Means, even after twenty, forty, an hundred, or any other Number of Years, provided their Organs are preserved intire? This Question future Experiments alone can answer.

Some late Discoveries serve to shew our Ignorance concerning the real Essence and Properties of what we term *Life*; and, if modestly considered, may contribute somewhat towards improving and inlarging our Ideas of it. These *Anguillæ*, the *Wheel Animal*, and I doubt not many other Kinds hitherto unobserved, are able to instruct us, that *Life*, or the *living Power*, may be suspended or cease to act for a Length of Time, and yet afterwards may be restored to its former Vigour. The cutting of the *Polype* and *Star-Fish* into Pieces, the Continuance of Life in those Pieces, and their reproducing all the Parts necessary to make each of them a perfect *Polype* or *Star-Fish*, prove beyond all Contradiction, I will not say that *Life* itself may be divided, (lest I should give Offence,) but that an Animal *possessed of Life* may be cut asunder, and the Parts thereof live afterwards, quite separate from and absolutely independent of one another; that all the Members wanting to each Part may be *reproduced*; that, in Time, each Part may become as large an Animal, and as perfect

to

to all Appearance, as that of which it was no more than a maimed and imperfect Part †; and beſides all this, that they may multiply, and produce young ones, in as great Numbers, and after the ſame Manner, as thoſe of that Kind that were never cut.—Theſe are Truths, the Belief whereof would have been looked upon ſome Years ago as only fit for *Bedlam*.

What Life *really is*, ſeems as much too ſubtile for our Underſtanding to conceive or define, as for our Senſes to diſcern and examine. We have, I think, no Criterion or ſenſible Proof whereby to diſtinguiſh *Life*, but *Motion*; and there certainly are Motions ſo *extremely languid*, that they can neither become the Object of our Eyes or our Ideas; therefore were *Motion* inſeparable from *Life*, (which is a Point we cannot I think determine) both might poſſibly exiſt in many Bodies where we ſuppoſe them not. But whatever be the *Eſſence of Life*, it is perhaps not to be deſtroyed, or really injured, by any Accidents that may befall the *Organs* wherein it acts, or the *Body* it inhabits. Dr. *Butler*, the late Biſhop of *Durham*, in his ingenious *Analogy of Religion to the Conſtitution and Courſe of Nature*, gives it as his Opinion, pag. 21, that "We have no "more

† The *Curious* may conſult on this Subject Dr. Parſons's *Obſervations on the Analogy between the Propagation of Animals and Vegetables*, pag. 200, &c.

" more Reaſon to think a Being endued " with *living Powers*, ever loſes them, dur- " ing its whole Exiſtence, than to believe " that a Stone ever acquires them."—" The " Capacity of exerciſing them for the pre- " ſent, as well as the actual Exerciſe of " them, may be ſuſpended, (ſays he, pag. " 22.) and yet the *Powers* themſelves re- " main undeſtroyed."

But leaving a Subject of which we know ſo little, to ſpeak ſomething farther of our *Anguillæ*:—It appears plainly from the foregoing Experiments, that when the blighted Grains of Wheat have been kept a long Time, and the Bodies of theſe Animalcules are conſequently become extremely dry, the Rigidity of their minute Veſſels requires to be relaxed very gently, and by exceeding ſlow Degrees; for we find, that on the Application of Water immediately to the Bodies of theſe Animalcules when taken from the dry Grains, they do not ſo certainly revive, as they do if the Grains themſelves be either buried in Earth or ſteeped in Water for ſome Time before they are taken out. The Reaſon of which moſt probably is, that too ſudden a Relaxation burſts their delicate and tender Organs, and thereby renders them uncapable of being any more employed to perform the Actions of Life. And indeed there are always ſome dead

ones amongſt the living, whoſe Bodies appear burſten or lacerated, as well as others that lie extended (in the Manner ſhewn before N° X. B.) and never come to Life, though we can't diſcover any ſenſible Injury they have received.

Some Diſcretion is needful, to adapt the Time of continuing the Grains in Water or Earth to the Age and Dryneſs of them; for if they are not opened before they have been too much or too long ſoftened, the Animalcules will not only ſeem dead, but will really be ſo. Of the two Grains I mentioned to have been four Years old when put to ſoak, I opened one after it had lain thirty-ſix Hours, and the Event was as already related: the other I let lie for above a Week, and on opening found all the *Anguillæ* near the Huſk dead, and ſeemingly in a decayed Condition; but great Numbers iſſued alive from the Middle, and moved themſelves briſkly.—— Unleſs the Huſks are opened to let theſe Creatures out after they have been ſteeped, they all inevitably periſh in them; and when taken out and preſerved in Water, if the Huſks are left with them, they will die in a few Days; but otherwiſe they will continue alive in Water for ſeveral Months together, and ſhould the Water dry away, may be revived again by giving them a freſh Supply.

Since

Since the Animalcules we find in *blighted Wheat*, as well as thoſe in ſour *Paſte*, are of an Eel-like Figure, it might be very eaſy (by ſuppoſing them both the ſame) to form plauſible Conjectures concerning the Production of *Eels in Paſte*, a Particular which at preſent ſeems ſo difficult to be accounted for: but as Truth ought to be the only Object of our Enquiries, I think myſelf obliged to ſhew wherein they differ, leſt others, who may not have the Opportunities or take the ſame Pains to examine them, ſhould poſſibly be miſled into ſuch Miſtakes by their being ſomewhat alike.

It is evident at firſt Sight, on their being viewed and compared together, that the *Anguillæ* of *blighted Wheat* are in general longer and a great deal ſlenderer than thoſe in *Paſte*, that their Motions are alſo much ſlower, leſs vigorous, and more diverſified: not inceſſantly wriggling the Head and Tail, as the *Paſte-Anguillæ* do, but lying ſometimes motionleſs, and coiling themſelves at other Times, more in the Manner of Serpents than Eels. They are alſo more tranſparent, and eſpecially for ſome Length from the two Extremities; but the moſt diſtinguiſhing Mark of all, is a very clear Part about the Middle of their Bodies, which approaches to an oval Figure when viewed in ſome Directions, tho' it more frequently appears tri-

angular, from its being preſented Side-ways to the Eye.

A B (*Plate* X. N° X.) repreſent a Couple of theſe *Anguillæ*. The Figure B ſhews how they lie extended, when they firſt are taken out from the Grain, and ſeparate in a Drop of Water, either before they begin to move, or when they are really dead.

A repreſents one of them alive and vigorous, and endeavours to ſhew the Manner of its moving. The tranſparent triangular Spot is pointed out in both *o o*.

CHAP. V.

Of the PROTEUS.

NONE, of the many different Animalcules I have yet examined by the Microſcope, has ever afforded me half the Pleaſure, Perplexity, and Surprize, as that I am going to deſcribe at preſent: whoſe Ability of aſſuming different Shapes, and thoſe ſo little reſembling one another, that nobody (without actually ſeeing its Transformation performed under the Eye) would believe it to be the ſame Creature, has given me reaſon to diſtinguiſh it by the Name of the *Proteus*.

When Water, wherein any Sorts of Vegetables

getables have been infuſed, or Animals preſerved, has ſtood quietly for ſome Days or Weeks, in any Glaſs, or other Veſſel, a ſlimy Subſtance will be collected about the Sides; ſome whereof being taken up with the Point of a Penknife, placed on a ſlip of Glaſs, in a Drop of Water, and looked at through the Microſcope, will be found to harbour ſeveral Kinds of little Animals that are ſeldom ſeen ſwimming about at large. The Inſect we are treating of is one of theſe; and was diſcovered in ſuch Slime-like Matter, taken from the Side of a Glaſs Jar, in which ſmall Fiſhes, Water-ſnails, and other Creatures had been kept alive two or three Months, by giving them freſh Water frequently; though the Sides of the Jar had ſeldom or never been wiped or cleaned.

Having one Evening been examining a little of this Slime, which I found plentifully ſtocked with ſeveral Kinds and Sizes of Animalcules that were to me no Strangers, ſuch as *Bell-Animals*, *Wheel-Animals*, *Funnel-Animals*, and others whereto as yet no Names are given; I was diverted with the ſudden Appearance of a little Creature whoſe Figure was intirely new to me, moving about with great Agility, and having ſo much ſeeming Intention in all its Motions, that my Eyes were immediately fixed upon it with Admiration. Its Body

in Subſtance and Colour reſembled a Snail's; the Shape thereof was ſomewhat elliptical, but pointed at one End, whilſt from the other a long, ſlender, and finely proportioned Neck ſtretched itſelf out, and was terminated with what I judged to be an Head, of a Size perfectly ſuitable to the other Parts of the Animal. In ſhort, without the leaſt Fancy, which is ever carefully to be guarded againſt in the Uſe of the Microſcope, the Head and Neck and indeed the whole Appearance of the Animal had no little Reſemblance to that of a Swan; with this Difference however, that its Neck was never raiſed above the Water, as the Neck of a Swan is, but extended forwards, or moved from Side to Side, either upon the Surface of the Water, or in a Plane nearly parallel to the Surface thereof.

N° XI. *Plate* X. 1. is an exact Repreſentation of this extraordinary Animal the firſt Time I ever ſaw it.

Its Size was about equal to that of the *Wheel-Animal*; whoſe general Form may be diſtinguiſhed well enough by the *fourth Glaſs* of Mr. *Cuff's Microſcope*, though the *firſt* is neceſſary to form a Judgment of its ſeveral Parts. It ſwam to and fro with great Vivacity, but ſtopped now and then for a Minute or two, during which Time its long Neck was uſually employed, as far as it could reach, forwards, and on every

Side, with a ſomewhat ſlow but equable Motion, like that of a Snake, frequently extending thrice the Length of its Body, and ſeemingly in ſearch of Food. *Fig.* 2. attempts to ſhew it as thus deſcribed, but is unable to expreſs the curious Turn and Elegance of its Shape.

I could diſcern no Eyes, nor any Opening like a Mouth in what appears to be the Head; but its Actions plainly prove it an Animal that can ſee; for notwithſtanding Multitudes of different Animalcules were ſwimming about in the ſame Water, and its own progreſſive Motion was very ſwift, it never ſtruck againſt any of them, but directed its Courſe between them, with a Dexterity wholly unaccountable, ſhould we ſuppoſe it deſtitute of Sight.

This Creature ſeemed to me ſo extraordinary, I could not forbear calling all my Family to ſee it. And after having viewed it by the *fourth Magnifier*, that being the Glaſs I was uſing when I firſt diſcovered it, we were very deſirous to examine it more ſtrictly by enlarging it ſtill more. Being therefore obliged to ſhift the Glaſs, which took up ſome little Time, I loſt my Animal as unaccountably as I had found it; all the Search I could make, for Half an Hour at leaſt, being unable to diſcover any thing bearing the leaſt Reſemblance to it: tho' I replaced the Glaſs I had employed before, and carefully travel-

ed over the whole Drop a great Number of Times. All I found remarkable therein, but which I regarded very little, was a pretty large Animalcule, that I remembered to have ſeen before what I was now ſeeking for had preſented itſelf to View, and whoſe Appearance was as at *fig.* 3. In a Word, after much Pains to no manner of purpoſe, concluding my new Acquaintance irrecoverably loſt, though I could not conceive how, I put the Microſcope aſide, very much diſappointed and diſſatisfied.

A Fortnight or three Weeks after, examining ſome more of the ſame ſlimy Matter, I was again ſurprized and pleaſed with another of theſe Animals, that ſtarted up under my Eye, and ſwam about as the former had done: but the Water it was in beginning to dry away, and being employed a few Moments in adding a freſh Supply, I loſt it as ſtrangely as I had done before, and looked for it again to as little purpoſe, till my Patience was wearied out.

Frequently, after this, I examined the ſame Matter, in hopes of finding ſome of theſe little Creatures, but all my Endeavours proved fruitleſs; and therefore, as I could give no better Account of them, I determined not to mention them at all. But one Night, ſhewing ſome other Animalcules in the beforementioned Slime, to my ingenious Friend

Friend Mr. *Turberville Needham*, (whoſe long Acquaintance with the Microſcope has made him equal at leaſt to any body in the Knowledge and Uſe thereof,) we fortunately and unexpectedly diſcovered one of theſe, and reſolved to watch it carefully by turns, and ſatisfy ourſelves concerning it as far as poſſible. Nor indeed were our Precautions needleſs; for when it had been ſwimming about a conſiderable while (in the Poſtures repreſented by *fig.* 1 and 2.) we beheld it on a ſudden draw in its Neck and Head in the Manner that a Snail does, ſo that both of them diſappeared intirely: its Body became then more opake, was ſhaped as *fig* 3. and moved about very ſlowly with the large End foremoſt.

I was now ſufficiently convinced how I had been before deceived by the Animal's diſappearing in one Shape, and appearing in another ſo extremely different. The Diſcovery we had made rendered us more eager to diſcover farther, and determined us not to leave it till it ſhould re-aſſume its former Shape. But we were ſtill more ſurprized, when, inſtead of ſo doing, we ſaw a Kind of Head (though quite unlike what it had before) thruſting itſelf out a little way; which new Head ſoon appeared furniſhed with a *Wheel-like* Piece of Machinery, the quick Motions whereof drew a Current of Water to it from a conſiderable Diſtance. The Animal in this Poſture is ſhewn *fig.*

Having

Having often pulled in and thruſt out this ſhort Head, ſometimes with and ſometimes without the *Wheel-work*, the Creature, as if weary, remained motionleſs for a while, and then very ſlowly protruded its long Neck under its own Body, as at *fig.* 5; ſoon after which it ſwam backwards and forwards extending its Neck, and turning it about every way with wonderful Agility, as if in ſearch of Prey. Twice or thrice it altered the Form of its Body, and diſpoſed its long Neck in the Manner of *fig.* 6.

Being now without Fear of loſing our Object, we changed our Glaſſes ſeveral times, and continued our Obſervations till we were fully ſatisfied of its Transformation; and the *Figures* herewith given were taken by my Son, (who has been much uſed to make Drawings from the Microſcope) during this Examination.

CHAP. VI.

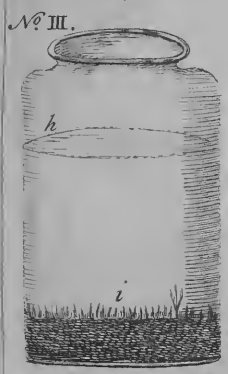
Of the WHEELER, *or Wheel Animal.*

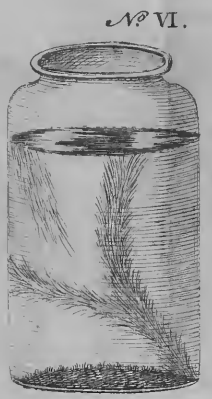
THE *Royal Society* having been pleaſed to accept very favourably a Deſcription of this little Creature, addreſſed to *Martin Folkes*, Eſq; their worthy Preſident; as I find no Reaſon ſince that time for altering any Part thereof, I ſhall give it here in the ſame Form and Words.

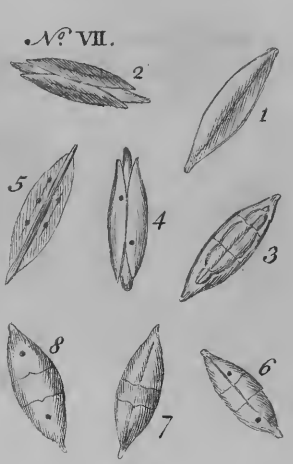
TO

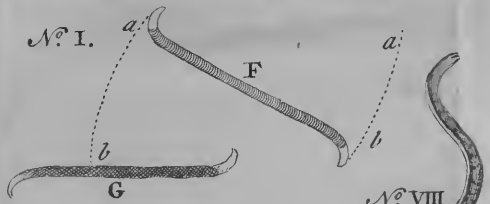
Plate X. *pa. 266.*

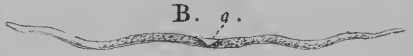
Animalcules.

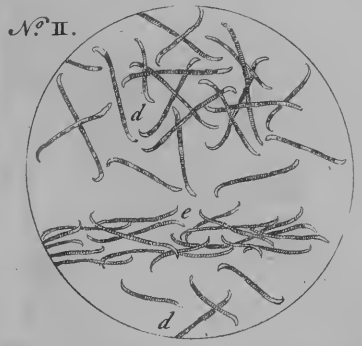


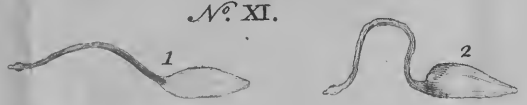


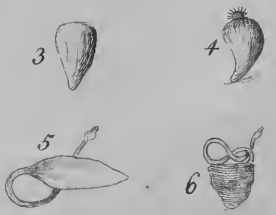












J. Myade sc.

TO

MARTIN FOLKES, Esq;

President of the *Royal Society*.

London, January 16th, 1744-5.

SIR,

I Take the Liberty to lay before you the best Account my Observations can at present furnish out, concerning that wonderful Water Insect the *Wheel Animal*, which you and several other of my curious Friends belonging to the *Royal Society* have often done me the Honour to examine by my Glasses, and admire along with me: and as it is extremely difficult to convey by Words only any true Idea of a Creature so very extraordinary, I have added exact *Drawings* of its different Forms, Postures, and Appearances; in hope, by that Means, of being understood by those who have never seen the Subject, as well as approved of by those that have: in Case you shall judge these Lines worthy to appear where you preside.

This wonderful little Insect is found in Rain Water, that has stood some Days in Leaden Gutters, or in Hollows of Lead on the Tops of Houses, or in the Slime or Sediment

diment left by such Rain Water; and if carefully sought after may be found also in other Places. Mr. *Leeuwenhoek*, that diligent Searcher into Nature, was the first Discoverer of it about fifty Years ago, (*viz.* in the Year 1702) soon after which he communicated an Account and Drawing thereof to the *Soyal Society:* both which may be seen in the 295th Num. of the *Philosophical Transactions.* What Regard was then paid to his curious Discovery I am wholly ignorant, but probably it was looked upon as a Matter of great Difficulty to find the Animal, and for that Reason little or no Enquiry was made after it, by the few who then amused themselves with *Microscopes:* however, from that Time till within these few Years (that People have begun to think the Works of their Creator, however minute, not unworthy of their Notice,) I question very much whether it has ever been seen by any one in *England.*

In order, therefore, to gratify the *laudable Curiosity* which at present diffuses itself amongst us, and seems the happy Omen of great Improvements in the Knowledge of Nature, I have not only shewn this amazing Animal to Numbers of Gentlemen at my own Home, but having by the Assistance of a more convenient *Microscope* for the Purpose than Mr. *Leeuwenhoek* probably was Master of, examined it with the strictest Attention, under

der all its various Appearances, and made ſeveral Obſervations thereon more than he has left us, the ſame Motive induces me to give the beſt Account thereof I can.

I call it a *Water Animal*, becauſe its Appearance as a living Creature is only in that Element. I give it alſo for Diſtinction ſake the Name of *Wheeler*, *Wheel Inſect* or *Animal*; from its being furniſhed with a pair of Inſtruments, which in Figure and Motion appear much to reſemble Wheels. It can, however, continue many Months out of Water, and dry as Duſt; in which Condition its Shape is globular, its Bigneſs exceeds not a Grain of Sand, and no Signs of Life appear. Notwithſtanding, being put into Water, in the Space of Half an Hour a languid Motion begins, the Globule turns itſelf about, lengthens by ſlow Degrees, becomes in the Form of a *lively Maggot*, and moſt commonly in a few Minutes afterwards puts out its Wheels, and ſwims vigorouſly through the Water in ſearch of Food; or elſe, fixing by its Tail, works them in ſuch a Manner as to bring its Food to it. But ſometimes it will remain a long while in the Maggot Form, and not ſhew its Wheels at all. ——The Drawings repreſent theſe different Changes; and I hope to ſhew how they are performed.

If the Water ſtanding in Gutters of Lead, or the ſlimy Sediment it leaves behind, has any thing of a red Colour, one may be almoſt certain

certain of finding them therein *, and, if in Summer, when all the Water is dried away, and nothing but Duſt remains, that Duſt appears red, or of a dark brown, one ſhall ſeldom fail, on putting it into Water, to diſcover Multitudes of minute reddiſh Globules, which are indeed the Animals, and will ſoon change their Appearance, in the Manner juſt now mentioned.

The Minuteneſs of theſe Animals makes it almoſt impoſſible to know whether you have them in the Water or not, without examining it by Glaſſes: the ſame Minuteneſs renders it alſo impracticable to ſeparate them from the Dirt or Slime found along with them, and on which perhaps they feed: in ſhort, they are intirely *microſcopical Inſects*, and whatever is ſaid concerning them muſt be underſtood to imply, as under Inſpection by the firſt or ſecond Magnifier of the Double Microſcope

My Way of diſcovering them is, by placing a ſmall Drop of the Water, wherein I know they are, with ſome of the Sediment therein, under the third or fourth Magnifier;

* *Wheel Animals*, though found with moſt Certainty in Leaden Gutters, &c. are often diſcovered in the Waters of ſome Ditches, and likewiſe in Water that has ſtood a conſiderable Time even in the Houſe: for I have often met with them, in ſufficient Plenty, in a Sort of ſlimy Matter, that is apt to be produced on the Sides of Glaſſes and other Veſſels, that are kept long with the *Infuſions of Hay* or other *Vegetables*; and probably they are wafted thither by the Air, when in the Condition of little dry Globules.

fier; and, when I have thereby found them, I change the Glaſs for one that ſhews them larger, and then watch all their Motions with great Attention.

This little Creature ſhews itſelf at firſt (unleſs it be in its Globule Form) like a tranſparent Maggot or Caterpillar, and appears lengthening out its Body conſiderably at ſome times, and at others contracting it as much. Its Motion from Place to Place is likewiſe then performed in the Manner of ſuch Inſects, fixing firſt its Tail and extending its whole Body, then faſtening its Head and drawing up its Tail to it: ſo that by fixing its Tail and puſhing its Body forwards, faſtening its Head and drawing its Tail thereto, alternately, it works itſelf along pretty nimbly. *Vid. fig.* 1. 2. *Plate* XI.

But one ſhall often behold it changing this Appearance in an Inſtant, and aſſuming a Form extremely different; for its Snout being pulled ſomewhat inward, the anterior End becomes clubbed, and immediately dividing, exhibits, moſt ſurprizingly, to view, a Couple of ſemi-circular Inſtruments, before unſeen, round the Edges whereof many little *Fibrillæ* move themſelves very briſkly, ſometimes with a kind of Rotation, and ſometimes in a trembling or vibrating manner. An Opening or Mouth alſo appears in the Middle between theſe two Semi-circles. When in this

this Condition, the Animal is often ſeen to unfaſten its Tail, and ſwim along with a great deal of Swiftneſs, ſeemingly in purſuit of Prey. *Vid fig.* 3.

The Subſtance of this Animal ſeems to be chiefly muſcular, every Part thereof being capable of great Diſtention and Contraction. It has likewiſe a conſiderable Degree of Tranſparency, whereby the Syſtole and Diaſtole of its Heart, and the periſtaltic Motion of the Inteſtines, are rendered plainly viſible: and a kind of Undulation may be perceived every where within it. It appears ſtrong and vigorous in proportion to its Size, and ſeems almoſt continually hunting after minute Animalcules or other little Bodies wherewith the Waters abound.

Fig. 1. ſhews the Form of the Inſect under Examination, when it appears like a Worm or Maggot, and fully extends its Body. Sometimes in this Condition little *Spiculæ* appear darted out at the Head End, with a Sort of vibrating Motion; the Snout is alſo ſometimes more flat, and ſharper at other Times, than repreſented here.

Fig. 2. deſcribes the Manner of its moving from Place to Place whilſt in the Maggot Form, by bringing the Head and Tail nearly together; then ſtretching the Body out, fixing the Head

Head down, and drawing up the Tail to it.

Fig. 3. exhibits the Inſect with its two ſemi-circular Parts put out, and exactly in the Poſture it places itſelf, when it prepares either to ſwim away, or to faſten by the Tail and work its Wheels about.

The general Account already given, will 'tis hoped render my Taſk the eaſier, now I come to examine the moſt diſtinguiſhing Parts of this Animal; *viz.* the *Head*, the *Thorax* or *Breaſt*, the *Abdomen* or *Belly*, and the *Tail*: each whereof I ſhall deſcribe with all the Perſpicuity and Brevity the Subject will allow.

The Faſhion and Conſtructure of the Head is wonderful, and extremely different from that of any other Creature hitherto deſcribed; its ſudden Change out of one Form into another is alſo unuſual and ſurprizing: for, from being perfectly tapering, and ending almoſt in a ſharp Point, like the Head of a common Maggot, it becomes on a ſudden as wide as any Part of the whole Inſect, opens a large Mouth, and is furniſhed by Nature with an amazing Piece of Machinery whereby to procure its Food.

One of theſe Animals, with the Head as here deſcribed, is repreſented *fig.* 4. where a Couple of circular Bodies, armed with ſmall Teeth like thoſe of the Ballance-Wheel

of a Watch, appear projecting forwards beyond the Head, and extending ſideways ſomewhat wider than the Diameter thereof. They have very much the Similitude of Wheels, and ſeem to turn round with a conſiderable Degree of Velocity, by which means a pretty rapid Current of Water is brought from a great Diſtance to the very Mouth of the Creature, who is thereby ſupplied with many little Animalcules and various Particles of Matter that the Waters are furniſhed with.

As theſe *Wheels* (for ſo from their Appearance I ſhall beg leave to call them) are every where exceſſively tranſparent, except about their circular Rim or Edge on which the Cogs or Teeth appear, it is very difficult to determine by what Contrivance they are turned about, or what their real Figure is, though they ſeem exactly to reſemble Wheels moving round upon an Axis.

It is alſo hardly poſſible to be certain whether theſe circular Bodies, round the Edges of which the Teeth are placed, are of a flat Form, or hollow and of a conic Figure. But they appear rather to be the latter, and if ſo they may be likened, not improperly, to a Couple of ſmall Funnels with Teeth ſet round their large Ends. However, be they flat or hollow, they ſeem plainly to be protruded from a Pair of tubular Caſes, into which they can be again retracted

tracted at the Will and Pleaſure of the Animal; and their Uſe undoubtedly is to procure it Food, by means of that *Current* or *Vortex* which the Motion of them excites. They turn not always in the ſame Manner, nor with equal Swiftneſs, neither is the Appearance of their Teeth or Notches conſtantly the ſame: for one ſhall ſometimes ſee them moving in contrary Directions, and ſometimes turning both the ſame Way. It is alſo not unuſual, after they have been moving one Way for a conſiderable Time, to behold them ſtop on a ſudden and turn directly contrarywiſe. Their ſeeming Rotation is ſometimes very faſt, and at other times very ſlow; increaſing or decreaſing ſometimes gradually, and ſometimes all at once.

The Teeth or Cogs of the Wheels ſeem to ſtand very regularly at equal Diſtances: but the Figure of them varies according to their Poſition, the Degree of their Protruſion, and perhaps the Will of the Animal. They appear ſometimes like minute oblong Squares riſing at right Angles from the Periphery of a Circle, like ancient Battlements on a round Tower; at other Times they terminate in ſharp Points, and all together reſemble a Kind of Gothic Crown. They are often ſeen in a curvular Direction, all bending the ſame Way, and ſeeming like ſo many Hooks: and now and then one ſhall

perceive the Ends of them to be clubbed, or in Appearance like a Number of little Mallets. This Figure, and the firſt, they however aſſume but rarely.

When the Forepart of this Creature firſt appears to open or divide, the Parts above deſcribed, which when fully protruded reſemble Wheels, and ſeem to have a quick Rotation, coming then but a little Way beyond their tubular Caſes, (and being in that Condition like round Pieces of Paper folded in the Middle, or Funnels whoſe Sides are flatted almoſt together,) ſeem only like a Couple of ſemi-circular Parts, about the Edges whereof, what are ſeen afterwards like the Teeth of the Wheels, appear only as little *Fibrillæ* or *Spiculæ*, having all a nimble and continual vibrating Motion upwards and downwards, whereby the Water becomes greatly agitated, and brought to the Animal from ſeveral times the Diſtance of its own Length. *Vid. fig.* 3. *

Before it begins to ſhew itſelf in this Poſture, it frequently faſtens its Tail to the ſlimy dirty Matter found with it in the Water, or elſe to the Glaſs whereon it is placed for View; and buoying up its Body in the Water, puſhes

* This *Vibration* commencing commonly ſome time before the *Wheel-Work* puſhes out and exerts its *rotatory Motion*, ſome People, not overſtock'd with Patience, have concluded, that it has no other Motion, than ſuch a *Vibration* of the *Fibrillæ*; but I am perſuaded a little more Attention will convince them of their Miſtake.

puſhes its Head forwards, directing it this Way and that Way with a great deal of Agility, and ſeemingly in ſearch of Food. In the mean while, many minute Animalcules and other little Bodies are drawn along with a rapid Current of Water, ſome whereof are taken in and ſwallowed, and others rejected, though brought to the Opening of its Mouth, which appears exactly in the Middle, between the two above deſcribed Semi-circles.

While the Sides of the Wheels are thus doubled as it were together, there is little or no Appearance of any circular Motion, the *Fibrillæ* about their Edges ſeeming to have only a quick Vibration: but moſt commonly, after two or three Minutes, this extraordinary Apparatus becomes protruded farther, the two Semi-circles puſh out, and open at the ſame Time, each of them immediately reſembles a compleat Circle or Wheel, ſeems to turn round very regularly, and its little *Fibrillæ* appear changed into Cogs or Teeth, in the Manner abovementioned.

As the Animal is capable of thruſting theſe Parts out, or drawing them in, ſomewhat in the Way that Snails do their Horns, the Figure of them is different in their ſeveral Degrees of Extenſion and Contraction, or according to their Poſition to the Eye of the Obſerver, whereby they not only appear in all the various Forms before repreſented, but ſeem at certain Times as if the circular Rim

of the Wheel or Funnel were of ſome Thickneſs, and had two Rows of Cogs or Teeth, one above and the other below that Rim.

When the Wheels appear in Motion, the Head ſeems large in proportion to the Size of the Animal; and tho' it is then every where tranſparent, a Ring or Circle, more particularly remarkable for its Clearneſs, may commonly be perceived about the Middle of the Forehead, a little above the Mouth. (*See figure* 5. *a.*) I ſhall not pretend to call this the Seat of the Brain, though its Situation and Appearance would perhaps juſtify ſuch a Suppoſition; but as I am fully ſenſible how very eaſy it is for me to be miſtaken, I am extremely fearful of leading others into Miſtakes. Many Veſſels which ſeem to take their Origin from hence are diſcernable in the Head, wherein ſome tranſparent Fluid appears continually agitated with a Sort of fluctuating Motion. All theſe Veſſels and every Part of the Head are capable of great Diſtention and Contraction, and frequently alter their Figure.

The Thorax or Breaſt *b*, is joyned to the Head by the Interpoſition of a ſhort annular Circle or Neck *c*, which is very plainly diſtinguiſhed when the Inſect is ſtretched out, and is working with its Wheels. This Thorax is nearly one ſixth Part of the whole Animal, and deſerves the moſt

moſt careful Examination; for as the Heart *d* may be ſeen therein more diſtinctly, its Figure and Motions may conſequently be obſerved much better in this than in any other ſmall Creature I have met with.

The Heart *d* is placed almoſt in the Middle of the Thorax, where its Syſtole and Diaſtole can't fail to catch the Eye of every attentive Obſerver; for it is ſeen through the Back of the Inſect very plainly, ſhutting and opening, alternately, with great Regularity and Exactneſs. Its Size is proportionable to the Creature's Bigneſs, and its Shape during the Syſtole or Time of Contraction is nearly circular, being compoſed ſeemingly of two ſemi-lunar Parts which then approach each other, laterally, and form between them a roundiſh or Horſe-ſhoe-like Figure, whoſe upper Side is flat, but the under one convex. The Diaſtole is performed by a ſeeming Separation or opening of theſe two ſemi-lunar Parts, whereby the tranſverſe Diameter of the Heart is very much enlarged. This Separation begins exactly in the Middle of the lower Part next the Tail, and opens to ſuch a conſiderable Width upwards, that the two Parts when at their utmoſt Diſtention ſeem only joyned by an arched Veſſel at their anterior End. The alternate Motions of Contraction and Dilatation are performed with great Strength and Vigour, in pretty much

much at the ſame Time as the Pulſations in the Arteries of a Man in Health; as I have often proved by feeling my own Pulſe whilſt I have been viewing them. In each of the ſemi-lunar Parts there appears a Cavity, which ſeems to cloſe when thoſe Parts come together, and to open itſelf again when they ſeparate.

The Motions of the Heart are communicated to all the other internal Parts of the *Thorax*; and indeed ſeem to extend a great deal farther; for a ſtrict Examination diſcovers, at the ſame Time, throughout the whole Animal, Contractions and Dilatations going on that are apparently correſpondent thereto.

It is however neceſſary to remark, that theſe Motions of the Heart are, ſometimes, as it were ſuſpended, or unperceiveable for two or three Minutes, after which they become renewed, and go on again with the ſame Vigour and Regularity as before. And this Suſpenſion of the Syſtole and Diaſtole, has made ſome Gentlemen to whom I have ſhewn it, doubtful, whether the Part we have been deſcribing can therefore be the Heart. But their Doubt ariſes wholly from a Suppoſition that the Hearts of minute Inſects muſt continue beating with the ſame Conſtancy, and be ſubject to the ſame Laws as the Hearts of the larger Kinds of Animals, which probably is not the Caſe.

The

The Situation, the Size, the Contraction and Dilatation of the Part we ſuppoſe to be the Heart, all concur in Support of that Opinion; but they can hardly all agree with any other of the Viſcera: and as to the Suſpenſion of its Motion, ſince in the Tortoiſe, the Viper, the Frog, and perhaps many other Creatures who become torpid at ſome Seaſons, the Motion of the Heart is ſuſpended or unperceiveable for a conſiderable Length of Time, there is no Abſurdity in believing that the ſame thing may happen to this Inſect, which is ſometimes in a torpid or inactive State as well as they, without doing it any Injury. Nay, that the Motion of its Heart (whether this Part be it or no) muſt unavoidably be ſuſpended, whilſt this very Animal is contracted into a Ball, and as dry as Duſt, is I think highly probable.

The Blood or circulating Fluid is ſo abſolutely colourleſs in this Creature, that the Current of it through the Veſſels is undiſtinguiſhable by Glaſſes, however likely it may ſeem, from the ſtrong Contraction of the Heart, that a Circulation muſt be carryed on, and that too very briſkly. One ſees indeed almoſt every where a ſort of irregular Agitation of ſome Fluid, which may be perhaps the compound Motion of Currents running different Ways and forming ſuch an

Appear-

Appearance, though no one ſingle Current is any where diſtinctly viſible.

From the under Part of the Thorax a ſmall tranſparent Horn proceeds, which can be never ſeen unleſs the Inſect turns on its Back or Side. I know not whether it be a Diſtinction of Sex, or to what other Purpoſe it may ſerve; for theſe minute Animals cannot poſſibly be ſo managed as to bring it under Examination when one pleaſes; and as it is only ſeen ſometimes by Accident, I cannot pretend to ſay whether all or ſome of them only are furniſhed therewith. It is ſhewn in the *Figures* 1 and 2. *a a.* being more commonly ſeen when the Creature is in the Maggot Shape than at other Times.

Immediately below the Thorax is another annular Circle or Diviſion *b*, joyning upwards to the Thorax, and downwards to the Abdomen; the Entrance whereof it ſerves occacaſionally to enlarge or diminiſh. This is ſhewn *fig.* 5. at the Letter *e.*

The Abdomen or Belly *f* is much the largeſt Part of the Animal, and contains the Stomach and Guts. When the Inſect is full of Food theſe Bowels appear opake and of a Blood-red or Crimſon Colour, extending in Length from the Thorax quite through the Belly and great Part of the Tail, and exhibiting a fine View of the periſtaltic Motion, or ſuch gradual Contractions and Dilatations as ſeem intended to propel

their

their Contents downwards. Around the Bowels are many Ramifications of Veſſels both longitudinal and tranſverſe; and between the Bowels and the Skin a Fluid exceedingly tranſparent fluctuates in a Manner Words cannot deſcribe.

The Belly is capable of ſtretching out greatly in Length, or being ſhortened very much and widening its Diameter: in ſhort it aſſumes many Shapes, and becomes, on Occaſion, a Caſe including the whole Animal, as will by and by be ſhewn.

From a Joynt at the lower Part of the Belly to the poſterior Extremity is what I call the Tail. (*Vid. fig.* 5. *g.*) It has three other Joynts, to the lowermoſt whereof the Bowels extend themſeves, and appear contracting and dilating upwards and downwards, though not ſo remarkably when they are empty as full. This Part runs tapering from the Belly to its End, and is lengthened or ſhortened at the Creature's Will. When it is inclined to fix itſelf by the Tail to any thing, (as commonly is its Way when it intends to work with its Wheels,) two, four, and ſometimes ſix little tranſparent Hooks or Fins may be ſeen thruſt out at its End, and ſerving for that purpoſe. They are placed in Pairs: one Pair is at the very Extremity, and the other two a little Way up the Sides: but the three Pair are ſeldom ſeen together.

Tho'

Tho' this Inſect ſwims very ſwiftly, and ſeemingly with great Eaſe, neither Legs nor Fins can be perceived to aſſiſt it in ſo doing, unleſs thoſe juſt now mentioned about the Tail, and the Horn under the Breaſt may be imagin'd ſuch. Wherefore ſince the Wheels in its Head are always ſet to work very briſkly whenever it begins to ſwim, one may reaſonably preſume they are the Inſtruments by which it performs this Office. And, indeed, looking at the Manner of its ſwimming through a Hand Magnifier, when it is at large in a Phial of Water, will confirm this Opinion greatly; for there one ſhall often diſcern it riſing in a perpendicular Direction, and by the Rotation of its Wheels climbing as it were upwards and mounting through the Water; but ſinking down again inſtantly upon the ceaſing of their Motion.

As I call theſe Parts *Wheels*, I alſo term the Motion of them a *Rotation*, becauſe it has exactly the Appearance of being ſuch. But ſome Gentlemen have imagined there may be a Deception in the Caſe, and that they do not really turn round, though indeed they ſeem to do ſo. The Doubt of theſe Gentlemen ariſes from the Difficulty they find, in conceiving how, or in what Manner, a Wheel, or any other Form, as Part of a living Animal, can poſſibly turn upon an Axis, ſuppoſed to be another Part of

of the ſame living Animal; ſince the Wheel muſt be a Part abſolutely diſtinct and ſeparate from the Axis whereon it turns; and then, ſay they, how can this living Wheel be nouriſhed, as there cannot be any Veſſels of Communication between that and the Part it goes round upon, and which it muſt be ſeparate and diſtinct from?

To this I can only anſwer, that place the Object in whatever Light or Manner you pleaſe, when the Wheels are fully protruded they never fail to ſhew all the viſible Marks imaginable of a regular turning round, which I think no leſs difficult to account for, if they do not really do ſo. Nay, in ſome Poſitions, you may with your Eye follow the ſame Cogs or Teeth whilſt they ſeem to make a compleat Revolution; for, the other Parts of the Inſect being very tranſparent, they are eaſily diſtinguiſhed through it. As for the Machinery, I ſhall only ſay, that no true Judgment can be formed of the Structure and Parts of minute Inſects by imaginary Compariſons between them and larger Animals, to which they bear not the leaſt Similitude. However, as a Man can move his Arms or his Legs, circularly, as long and as often as he pleaſes, by the Articulation of a Ball and Socket, may not there poſſibly be ſome Sort of Articulation in this Creature whereby,

whereby its Wheels or Funnels are enabled to turn themſelves quite round * ?

Having deſcribed the moſt remarkable Parts of this Inſect, I ſhall by the four following Figures endeavour to repreſent ſome other of the moſt uſual Forms it aſſumes, both when its Wheels are fully protruded, and when the Edges only of them are ſhewn with their little vibrating *Fibrillæ*.

Fig. 6. is the *Wheel Inſect* raiſing itſelf on the Tail, ſtooping the Head downwards, and working its Wheels about. This is a common Poſture, in which the Back is bowed, and the Belly appears ſhortened and diſtended, great Part of the Thorax being taken into it. The Wheels in this Poſition ſeem to turn horizontally, with their Backs upwards and towards the Eye, in which Manner they appear very diſtinct and large, with their Teeth bending all the ſame

* It is certain all Appearances are ſo much on this Side the Queſtion, that I never met with any who did not on ſeeing it call it a *Rotation* ; tho' from a Difficulty concerning how it can be effected, ſome have imagined they might be deceived: Mr. *Leeuwenhoek* alſo declared them to be *Wheels* that *turn round*; vid. *Phil. Tranſ.* N° 295. But I ſhall contend with nobody about this Matter : it is very eaſy for me I know to be miſtaken, and ſo far poſſible for others to be ſo too, that I am perſuaded ſome have miſtaken the *Animal itſelf*, which perhaps they never ſaw, whilſt inſtead thereof they have been examining one or other of the ſeveral *Water-Animalcules* that are furniſhed with an Apparatus commonly called *Wheels*, tho' they turn not round, but excite a Current by the *mere Vibration* of *Fibrillæ* about their Edges.

ſame Way, and reſembling as many Hooks. The different Parts of the Animal as before deſcribed are explained by this Figure.

Fig. 7. ſhews the Animal turned with its Side towards the Eye, as it frequently preſents itſelf. The Wheels here have the ſame Appearance as in the preceding Figure: but one of them lies conſiderably below the other, the whole Body being ſomewhat twiſted, whereby the Horn under the Thorax is diſtinctly brought to View.

Fig. 8. and 9. exhibit two of theſe Creatures in the Poſtures they are often ſeen, when the Wheels are not thruſt out, but the *Fibrillæ* appear moving up and down with very quick Vibrations. We ſee particularly in *fig.* 9. the whole Space between theſe Parts gaping like a wide Mouth, and different from any of the former Figures.

To deſcribe the many Poſtures I have ſeen this Creature in would be a Waſte of Time; but the Manner of its changing, when it pleaſes, into a round Globule or Ball, is ſo remarkable a Part of its Hiſtory, that I muſt attempt to give the beſt Account of it I can; as I have many times obſerved very attentively every Step in its Metamorphoſis.

After

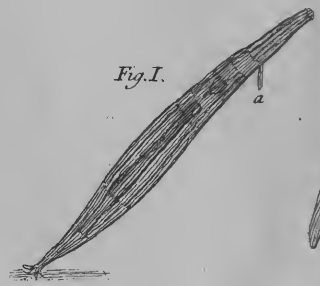
After having turn'd about its Wheels, in various Directions, for two or three Hours, in the Water, and probably fill'd its Belly, (during which Time its Tail remains faſtened to ſome Dirt or Slime, or to the Slip of Glaſs it is placed upon:) one ſhall perceive it, by Degrees, moving them with leſs Vigour, and at laſt drawing them quite within the Head. The Head and included Wheels ſink down then very ſlowly into the Thorax, the Belly ſwells, and the whole appears like *fig.* 10.

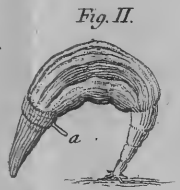
Soon after, the Thorax alſo (which now contains the Head and Wheels) is drawn within the Belly, and below the annular Circle at the Top of it, as *fig.* 11. repreſents.

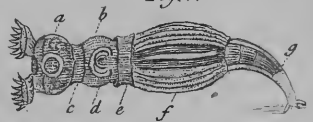
The ſaid annular Circle then contracts, and its Sides come together like the Sides of a Purſe when the Strings are pulled, cloſing over the Head and Thorax, which, now, filling the upper Part of the Belly make it nearly round, like *fig.* 12.

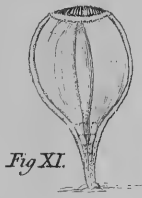
In the laſt Place, the three upper Joynts of the Tail come down over the lower Joynt which becomes fixt; immediately the Belly alſo ſinks, or is pulled down, and incloſes the whole Tail. All the Parts being now included in the Belly, which becomes their Caſe or Covering, it ſwells into a round Ball, lies without any Motion, and appears conſiderably opake. (*Vid. fig.* 13.) It ſtill adheres however by the Tail. Some-

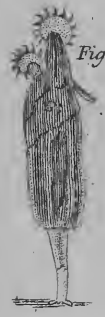
The Wheel Animal in its several Postures











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Sometimes, when in the Maggot Form, it rolls its Head and Tail together, without drawing them into its Body; in the Manner of *fig.* 14.

All my Endeavours have been hitherto unable to diſcover how theſe Creatures propagate, though for three Years paſt I have never been without them, and am continually ſenſible of their Increaſe, by obſerving Numbers of extremely ſmall ones appearing from time to time: which undoubtedly are young Fry. There's however good Reaſon to believe they proceed from Eggs: for I have often ſeen, in the Water along with them, Parcels of Ova, gelatinous like the Spawn of Frogs, and of a Size proportionable to the *Wheel Animal*.--But after whatever Manner they are propagated, 'tis pretty certain, from the exceeding Minuteneſs of ſome in Compariſon of others, that they come out at firſt in their perfect Shape, and are not the *Nymphæ* of any other Inſect, as many Creatures found in the Waters are.

Mine have conſtantly been kept in the ſame Glaſs Veſſel, ſometimes with and ſometimes without Water: for as the Sides of the Glaſs were often left dry, I have ſuffered thoſe that had faſtened themſelves there to remain ſome Months in that Condition: nevertheleſs, I always found them to become as lively as ever on giving them freſh Water. Mr. *Leeuwenhoek* kept ſome Dirt, taken out of a Leaden Gutter, and dried as hard as

Clay, for twenty-one Months together; and yet when it was infuſed in Water, Multitudes of theſe Creatures ſoon appeared unfolding themſelves, and quickly after began to put out their Wheels: and I myſelf have experienced the ſame with ſome that had been kept much longer.

All their Actions ſeem to imply Sagacity and Quickneſs of Senſation. At the leaſt Touch or Motion in the Water they inſtantly draw in their Wheels. Notwithſtanding their Smallneſs, one ſees ſeveral Species of Animalcules ſwimming in the Water with them, compared to which themſelves appear like Whales. Theſe Animalcules are their Prey: which they take either by Purſuit, or draw to them by the Current of Water which their Wheels excite.

It has conſtantly been my Endeavour to diſcover the Eyes of this Creature, but I have never been able to diſcern that it has any. And yet, when one beholds it ſwimming along with great Swiftneſs, turning its Head on every Side, and ſeemingly purſuing its Prey, avoiding any Dirt or other Matters in the Water that would obſtruct its Paſſage, and directing its Courſe with as much ſeeming Care, Choice, and Conduct as Animals that have Eyes do, one can hardly think it deſtitute of Sight.

I would induſtriouſly avoid giving way to Fancy in Caſes of this Nature, but muſt acknow-

acknowledge my ſuſpecting that it has Eyes ſomewhere within its Wheels: and my Reaſons for this Suſpicion are, its blundering, irregular, and ſlow Motions while it appears in the Form of a Maggot, before its Wheels are put out, and the Regularity, Swiftneſs, and ſteady Direction of its Motions afterwards: whereto I might add, that when it ſwims along its Wheels are always out. Beſides, all the Creatures we know that move themſelves from Place to Place with Swiftneſs, either by running, flight, or ſwimming, are remarkable for their keenneſs of Sight; and indeed it ſeems probable that the ſame Rule may hold through all the Animal Creation: for, as the Gifts of Providence are ever ſuited to the Exigencies of its Creatures, and contrived in the beſt manner for their Preſervation, we can ſcarcely imagine Swiftneſs is beſtowed on any without the additional Bleſſing of Sight to direct its Courſe; ſince the former without the latter muſt unavoidably precipitate the Creature into continual Danger of Deſtruction.—This makes me ſuppoſe it may poſſibly have Organs of Sight ſomewhere about the Wheels: nor is there any thing more extraordinary in that than in the Eyes of Snails, which are generally allowed to be placed at the Extremities of their Horns, and conſequently muſt be thruſt out and drawn in with them.

I cannot conclude this Subject without doing all the Honour I am able to the Me-

mory of Mr. *Leeuwenhoek*, by repeating, that we are obliged to his indefatigable Induſtry for the firſt Diſcovery of this moſt ſurprizing Inſect.

CHAP. VII.

Different Kinds of WHEEL ANIMALS.

THERE are found in the Waters ſeveral other Kinds of Animalcules, furniſhed with Inſtruments for making an Eddy, and thereby bringing to themſelves ſuch minute Inſects, or very ſmall Particles of Matter, as ſerve them for Food. Among theſe ſome appear to have a *rotatory* and others a *vibrating Motion*; ſome alſo ſeem capable of being employed both ways.

In the Ditch-Water ſent me from *Norwich*, as before-mentioned *pag.* 233. I diſcovered ſeveral *Wheel Animals* with Tails enormouſly long, but in all other Reſpects, as far as I could diſcern, differing not at all from thoſe juſt now deſcribed; the Motion of the Wheels, the Pulſation of the Heart, and the Undulation of the Bowels appearing exactly the ſame in both: Nothing therefore ſeems farther neceſſary than to give the Picture of them, which ſee *Fig.* 1. *Plate* XII.

Fig. 2 and 3 in the ſame *Plate*, repreſent two different Sorts of Animalcules, ſeveral whereof were found ſome Years ago, in Water

Water taken out of a Leaden Ciſtern that ſtood in *Somerſet Garden*.— The anterior Part in the firſt of theſe has a large Opening, ſurrounded with ſharp *Spiculæ a*, and is evidently cruſtaceous, though the Body and Tail are muſcular. It is not eaſy to diſcern the Inſtruments within this Mouth or Opening that ſerve to form a Current of Water, as the Creature does not thruſt them beyond the Neck *b*. When it ſwims along it ſeems extremely formidable to the minuter Animalcules, Multitudes of which are frequently ſucked in, together with a great deal of Water, which is ſpouted out again immediately. When the Tail is faſtened to ſomething, it turns the Body about and directs its wide Mouth to every Side, and brings a Stream of Water from a conſiderable Diſtance. The Motions of the Bowels are diſtinctly viſible in this Animal; and within ſeveral of them one may ſee an opake oval Body *c*, which by its Size and Appearance I imagine to be an Egg; which if it is, it ſignifies their Increaſe to be much leſs than that of moſt other minute Animalcules; for I never obſerved more than a ſingle one in any of them; and indeed I never found the Creatures themſelves in very great Number. They are ſomewhat larger than the common Wheel Animal.

Fig. 3. repreſents an Animalcule found in the ſame Water with the former, and reſembling it pretty much in the Size and

Shape of its Body, though its Head and Tail are different: for this Creature's Tail is furniſhed with a Couple of Inſtruments *a a*, that lie ſheathed therein, unleſs when they are made uſe of to faſten it to any thing, that it may the better be enabled to occaſion an Eddy of Water and bring its Food to it with the Stream. During the Time it is ſo employed the Body appears extended (as in the Figure) and a Number of *Fibrillæ*, protruded from two projecting Parts *b b* that compoſe the Head, put the Water into a violent Motion, and excite a Current, by their vigorous and quick Vibrations, which ſets directly towards the Mouth *c*.

This little Creature is entirely muſcular, and frequently changes the Form of its Appearance by contracting its Body and pulling in its Head or Tail. The periſtalic Motion of its Bowels, which are conſiderably opake, is ſeen working upwards and downwards in an odd manner, but no Part can with any Certainty be known to be either Lungs, Heart, or Stomach. In many of them however, an oval Body, which I gueſs to be an Egg, is very diſtinguiſhable, contained ſeemingly in a *Uterus*, or Veſſel, that ſeparates it from the other Bowels. They lived with me ſeveral Days in the Water they were brought in, but I could never be ſo lucky to ſee any of theſe Eggs, (if ſuch they are) diſcharged from the Animal.

CHAP.

CHAP. VIII.

Animalcules with Shells and Wheels.

IN the Summer of the Year 1745, I firſt took notice of three Sorts of *Wheel Animals** having Shells, which I found herding together in the Water of the Ciſtern in the Garden of *Somerſet Houſe*, and have ſeen ſince in other Waters. The firſt of them is repreſented by the Figures 4, 5, 6: the ſecond Sort by thoſe 7, 8, 9, 10: and the third Sort are marked 11, 12, 13. *Plate* XII.

The firſt Sort when extended is in Length about twice its Breadth. It is contained in a Shell, whoſe Fore-part or End is armed with four very long Spikes on one Side of its Rim, the other Side whereof has no Spikes, but is waved or bent in two Places, much like the Form of a Turkiſh Bow: *vid. fig.* 6. The poſterior End has a large circular Hole through which the Tail is put out. By this Tail it faſtens itſelf to any thing it meets with, when it intends to ſet the Wheel-work at its Head in Motion; but in ſwimming, and at all other Times when it is not fixed by it, it wags this Tail backwards and forwards as a Dog does his,

* Theſe are called *Wheel Animals*, from their reſembling the foregoing in ſome Particulars.

and makes uſe of it on other Occaſions, which we ſhall preſently take notice of.

Its Body ſeems divided into three Parts, the Head, Thorax, and Abdomen; each whereof is capable of great Diſtention and Contraction; the Creature being able by extending them all three to protrude its Head beyond the Shell, and on contrary, by contracting them, to draw its whole Body a great way within the ſame.

The Head when extended divides into two Branches, between which another Part (a Kind of Proboſcis) is puſhed out, at whoſe End are two Fibrils, that appear when at Reſt like one very broad Spike, but which it can move very briſkly to and from each other with a *vibrating Motion*, bringing thereby a Stream of Water to its Mouth, whoſe Situation is juſt betwixt them. And the better to effect this, ſeveral of the like *Fibrillæ* are placed on each Side of the Head, which *vibrate* in the ſame Manner, as do likewiſe ſome very ſmall ones at either Corner. All this may be underſtood by viewing *fig.* 4.

But ſometimes it alters the Form of the two Branches, rounding the Ends thereof, and changing the vibrating Motion of its *Fibrillæ* into a Rotation, or at leaſt what ſeems to be ſo; at which Time the Head appears as at *fig.* 5.

Imme-

Immediately to the lower Part of the Head the Thorax is joyned, ſeemingly of a muſcular Contexture, and containing within it an Inteſtine, which by its Motions muſt be either the Lungs or Heart of the Animal; *ſee b. fig.* 4. and 5.

A Communication between the Thorax and the Abdomen or Belly is continued by means of a ſhort Veſſel *c*, whoſe alternate Contractions and Dilatations occaſion the Abdomen to riſe and fall alternately, having at the ſame time a Sort of periſtaltic Motion. Through this Veſſel or Gut all the Food the Animal takes in is conveyed directly to the Abdomen, where it becomes digeſted, and is then diſcharged by the Anus, which is placed ſomewhere near the Tail; but we have not yet been able to diſcover exactly where, for the Fæces are thrown out ſometimes at the lower Opening of the Shell, and ſometimes they are carryed upwards (between the Shell and the Body of the Animal) and caſt out with a conſiderable Force at the other End, by the Motions of the *Fibrillæ*, which the Animal can employ to form a Current, not only towards him but from him.

The Tail has three Joynts, and is cleft or divided at its Extremity, by which means it can the better faſten to any thing. It is ſeen moſt commonly iſſuing through the Hole at the lower End of the Shell, wagging nimbly

bly to and fro, and is made uſe of in ſwimming to ſteer or direct its Courſe: but when the Water wherein the Animal abides is almoſt dryed away, or when it has a mind to compoſe itſelf to reſt, it contracts the Head and Fore-part of the Body downwards, and pulls the Tail upwards, in ſuch a Manner that the whole Animal is brought intirely within the Shell: and at ſuch times only the anterior Edges of the Shell, and the Spikes proceeding therefrom, can be fully diſtinguiſhed, and determined to be as repreſented *fig.*6. whoſe Deſcription was juſt now given. For the Shell is ſo extremely tranſparent that its Terminations cannot be ſeen when the Inſect extends beyond it; but whatever paſſes within it is as plainly viſible as if there was no Shell at all.

Fig. 7, 8, 9, and 10, ſhew the ſeveral Appearances of the ſecond Species of theſe ſhelled Animals having Wheels, which differs from the firſt in ſome Particulars now to be deſcribed.

The Body of this Species conſiſts of three Parts, in like Manner as the other does; only the Thorax and Abdomen are not in this ſeparated by a Gut or intermediate Veſſel as they were in that, but are joyned immediately together; and at that Place in the Thorax, where, in the other Species, I have deſcribed an Inteſtine, which I ſuppoſed to be either the Lungs or Heart, an Heart is plainly perceived

ceived in this, having a regular Syſtole and Diaſtole, and nearly of the ſame Form and Size with the Heart of the common *Wheeler*. as the *Figures* 7, 8, and 9, are intended to ſhew at the place marked *a*.

This Species likewiſe draws its Head and Tail occaſionally within the Shell, as at *fig*. 10; and then its Shell appears terminated on its Fore-part by ſix ſhort Spikes on one Side of the Rim and two on the other, inſtead of the four long ones wherewith the firſt Sort is armed: but this does not always protrude its Head like the other, ſo far out as to cover the Edges of the Shell intirely: ſometimes on the contrary, the Spikes of the Shell are ſeen beyond the Head, and the *Fibrillæ* mentioned in the former Deſcription appear playing between them, as at *fig*. 7. However the Head very commonly is as at the *Figures* 8 and 9.——Theſe are the chief Particulars wherein this Animal differs from the former.

As to their Propagation, both Species carry their *Young* in oval *Sacculi* or Integuments, faſtened, externally, to the lower Part of their Shells ſomewhere about the Tail: Theſe Sacculi are ſometimes opake only at one End, and ſeemingly empty at the other, ſee *fig*. 5: Sometimes the Middle Part appears opake with a Tranſparency all round, like *fig*. 7; and much Variety of Darkneſs and Tranſparency may be diſtinguiſhed, according

cording to the different Maturity of the Embrios in these Bags.

It is highly entertaining to see a young one burst its Integuments, and gradually force its Way through them: in doing which the Parent is greatly assistant, for by wagging her Tail to and fro, and striking the Shell, Skin, or Covering, briskly therewith, the young one's Head Part becomes as it were squeezed forwards into the Water, tho' the Tail cannot so soon be disengaged. In this Condition the young one sets its Wheels a-going, and exerts all its Endeavours, 'till at last it frees itself from Confinement, and swims away, wagging its Tail as the old one had done before it, and leaving the Integument adhering to the Shell of the Parent; who then uses abundance of Contrivances and Efforts to get rid of it, striking against it with her Tail, fixing the End of her Tail thereto and darting her Body forwards, with several other very odd Motions not easy to be described.

A young one almost disengaged from the Shell, being fastened thereto only by the Tail, is shewn *fig.* 9. *b.* The Subject from whence this Picture was exactly taken, during the Performance of all the Particulars above described, had also another *Embrio c* adhering to its Shell.

These Animals have one, two, three, nay sometimes even four or five of these young ones

ones hanging to them: but they are frequently without any at all, like the Figures 4 and 8.

The third Species of cruſtaceous Animals with Wheels, ſhewn *fig.* 11, 12, 13. is remarkably different from the former two in the Shape and Faſhion of its Shell, which extends on either Side a curved or hooked Proceſs, that bending towards the Tail, inward, ends in a ſharp Point, and is within a fourth as long as the Tail itſelf.—The Head-Part of the Shell differs alſo from thoſe before deſcribed, in the Order and Diſpoſition of the *Spiculæ*, of which it has four longer and two ſhorter ones, placed as in *fig.* 13. where by the Body's being contracted and drawn conſiderably within the Shell, as frequently is the Caſe, the Top of the Shell is perfectly diſtinguiſhable, and its *Spiculæ* plainly ſeen.

The Tail of this Creature has the like Figure, Articulations and Motions with that of the other Species: and its Body may properly be divided in the ſame Manner as theirs, though in Shape it appears ſomewhat different through the Shell, which the Drawings expreſs ſufficiently without any particular Deſcription.

From its Head two Arms or Branches are frequently extended, and the circular End of each is furniſhed with a Border of *Fibrillæ*, ſeeming at ſome times to have a very quick Vibra-

Vibration, and at others a rotatory Motion, occaſioning a rapid Current in the Water.

Their Ova are carried at the Tail End, either faſtened to the Tail itſelf, or to the Proceſſes of the Shell, as at *fig.* 12. One, two, or three are the Number uſually hanging to them; but ſome, though very few, have four or five. The *Young* burſt their Integuments, and are hatched very probably like the Species before deſcribed; but having never had the Pleaſure of ſeeing them do ſo, I can ſay nothing more to this Part of their Natural Hiſtory.

CHAP. IX.

The Water-Flea *with* branched Horns.

A True Figure and Deſcription of this little Creature having never yet been publiſhed amongſt us, what follows I hope may prove acceptable.

The Name given it by *Swammerdam* of *Pulex aquaticus arboreſcens*, I chuſe to retain here, as expreſſing aptly enough its Motions and Appearance.—It is found in Reſervoirs of Rain Water, in Baſons, Ponds, Ditches, *&c.* where the Water is not often renewed; and that ſometimes in ſuch Abundance, as

by

by its red Colour to make the whole Surface of the Water appear like Blood †.

This Animal is cruſtaceous, being covered with a thin oval Shell in the manner of a Lobſter or Cray-Fiſh, but with this Difference, that the Shell being open a good part of its Length, the Animal can thereby put out and draw in its Legs and part of the Body when it pleaſes.

The upper Part of the Shell bears a near Reſemblance to the Head of a Bird, having a ſharp-pointed Proceſs very much like a Beak or Bill, but intirely fixt and immoveable; and the Eye being placed near thereto, in a Situation much correſponding with that of a Bird, adds much to the Reſemblance. This Eye ſeems compoſed of ſeveral ſmall Globules, though not pearled as thoſe of Land Inſects, but all contained in one Integument, wherein they appear to be in ſome Degree moveable. The Animal has two of theſe Eyes: but as he always lies on one Side when placed in a Drop of Water to be examined by the Microſcope, no more than one can then be ſeen; which induced Mr. *Bradley* to imagine it had only one Eye, and from thence to call it *Monoculus*; but whoever beholds the monſtrous Picture that Writer

† Some Swarms of them are red, and others green; but whether this Difference be owing to their Food, or ſome other Accident, or whether they are of different Species, I am unable to determine.

Writer has given of this Insect in his Book on the *Works of Nature*, will be little surprized at any of his other Mistakes.

A little below the Eyes, two Horns, which are moveable, are joined to the shelly Head; their Insertion being in the Manner of Ball and Socket. Each of these Horns comes out in one single Trunk at first, but divides soon into a Pair of Branches, each Branch having three Joynts. A small Hair Bristle grows out from either of the two first Articulations, and three pretty long ones from the Extremity of the last.

Just beneath the Insertion of these Horns a long kind of Gut runs down almost the Length of the whole Body, where it joyns to a Part which in Shape very much resembles the Toe of a Bird, having a large Claw or Talon at the End thereof. The Creature can move this part beyond its Shell with a great deal of Force, and by that means, as I apprehend, performs its springing or leaping Motion.

It has eight Legs or Fins besides this, which, when the Creature lyes otherwise still, are nevertheless in a continual and nimble Motion, forming a brisk Current of Water, like that of many other Animals. They are also very serviceable in swimming, and assist in its circular Motion, of which I shall presently speak.

Behind the abovementioned Gut, and as it were detached from the reſt of the Body, the Heart is placed, and may be ſeen dilating and contracting, alternately, with a very regular and diſtinct Syſtole and Diaſtole.

The lower Part of the Shell terminates in a long Spike or Tail, which is without Motion, but thickly ſet with ſix Rows of ſhort ſtrong Spines, making its Appearance like the prickly Horn or Snout between the Eyes of Lobſters, Cray Fiſh, Shrimps, *&c.*

Swammerdam has very judiciouſly obſerved *, (what every body who examines it carefully will diſcover to be true) that this Animal has three different Kinds of Motion. The firſt is a ſmooth and even ſwimming, whereby it carries itſelf horizontally along in the Water. The ſecond is a ſudden ſkipping or leaping, much reſembling that of a Flea. And the third is, when lying at the Bottom of the Water, it turns its whole Body round as it were on a Center, with a very briſk Rotation, by means of its ſmall Legs or Fins.

As no Creature lives without its Tormentors, this is very much infeſted by the *Shelled Wheel Animal* already deſcribed *Page* 298, and ſhew in the *Plate* with this, *fig.* 7, 8, 9. Both theſe Inſects are in great Abundance frequently in the ſame Water; and when that

* Hiſt. Gen. des Inſectes, p. 69, 70.

is the Caſe, 'tis not uncommon to diſcover five or ſix of the *Shelled Wheel Animals* faſtened by their Tails to the Shell or Horns of the *Water-Flea*, and cauſing to it ſeemingly a vaſt deal of Uneaſineſs; nor can they be driven away, or ſhaken off, by all the Motions and Efforts the Creature makes uſe of for that Purpoſe.

CHAP. X.

The Bell-Flower Animal, or *Plumed Polype*.

I Was firſt informed of this Creature by my induſtrious Friend Mr. *William Arderon*, towards the End of the Year 1743, as his Letters ſhew; and in the Year 1744, it was taken notice of by Mr. *Trembley*, who gave it, in his *Memoires*, the Name of the *Polype a Pannache*, or the *Plumed Polype*. My Friend, who diſcovered it in his Searches for the *Polype*, called it the *Bell-Flower Animal*; and after favouring me with his own Obſervations, ſent me ſome of the Creatures themſelves, which living with me ſeveral Months, I had ſufficient Time and Opportunity to examine and conſider them. And as there ſeems ſome little Difference between thoſe in my keeping, and what Mr. *Trembley* deſcribes, they may poſſibly be of another Species, tho' of the ſame Genus.

This

This is one of the many Kinds of Water Animals which live as it were in Societies; of which ſome Sorts hang together in Cluſters, but can detach themſelves at Pleaſure; whilſt others again are ſo intimately joyned and connected together, that no one ſeems capable of moving or changing Place without affecting the Quiet and Situation of all the reſt. But this Creature forms as it were an intermediate Gradation between the other two, dwelling in the ſame *general Habitation* with others of its own Species, from whence it cannot intirely ſeparate itſelf; and yet *therein* it appears perfectly at Liberty to exert its own voluntary Motions, and can either retire into the common Receptacle, or puſh itſelf out from thence and expand its curious Members, without interfering with or diſturbing its Companions.

They dwell together, from the Number of ten to fifteen, (ſeldom exceeding the latter or falling ſhort of the former Number) in a filmy Kind of mucilagenous or gelatinous Caſe; which out of the Water has no determined Form, appearing like a little Lump of Slime, but when expanded therein, reſembles nearly the Figure of a Bell with the Mouth upwards; and is uſually about the Length of half an Inch, and one Quarter of an Inch in Breadth or Diameter. This Caſe being very tranſparent, all the Motions of its Inhabitants may be diſcerned through

it distinctly. It seems divided, internally, into several Apartments, or rather to contain several smaller *Sacculi*, each of which incloses one of these Animals. The Openings at the Tops of those *Sacculi* are but just sufficient to admit the Creature's Head, and a very small Part of its Body, to be thrust out, beyond them, the rest remaining always in the Case. The Animal can however when it pleases draw itself intirely down within the Case, which is an Asylum to secure it from its Enemies, (for 'tis not unlikely many of the larger aquatic Insects prey upon it) and a safe and agreeable Retirement wherein to perform the Functions of Digestion, Sleep, and the other necessary Calls of Nature. This Case it can, I say, retire into at Pleasure; and it never fails to do so when any sudden Motion of the Water, or of the Vessel it is in disturbs it: as also when it has seized with its Arms any of the minute Insects which serve for its Food.

The Arms are set round the Head to the Number of forty, having each the Figure of a long *ſ*, one of whose hooked Ends is fastened to the Head; and all together when expanded compose a Figure somewhat of a *Horſe-ſhoe* Shape, convex on the Side next the Body, but gradually opening and turning outwards, *(ſee fig.* 19 and 20. *Plate* XII.) so as to leave a considerable Area within the outer Extremities of the Arms. And when thus

thus extended, by giving them a vibrating Motion, the Creature can produce a Current in the Water, which brings the Animalcules, or whatever other minute Bodies are not beyond the Sphere of its Action, with great Velocity to its Mouth, whoſe Situation is between the Arms: where they are taken in, if liked, or elſe by a contrary Current, which the Creature can excite, they are carried away again: whilſt at the ſame time other minute Animalcules or Subſtances, that by lying without ſide the Incloſure made by the Arms are leſs ſubject to the Force of the Stream, are frequently ſeized by them: for their Senſe of Feeling is ſo exquiſite, that on being touched ever ſo ſlightly by any ſuch little Body, it is caught immediately and conveyed to the Mouth. However, one may obſerve the Creature is ſometimes diſappointed in its Acquiſition: for after drawing down one of the Arms ſuddenly inwards towards the Mouth, it may be perceived ſlowly extending itſelf again, without the Creature's retiring into its Caſe; which it fails not to do on meeting with any thing worth its while.

The Food is conveyed immediately from the Mouth or Opening between the Arms, through a very narrow Neck, into a Paſſage ſeemingly correſpondent to the Oeſophagus in Land Animals; down which it paſſes into the Stomach, where it remains for ſome

Time, and then is voided upwards, in ſmall round Pellets, (which at firſt I imagined to be its Eggs) through a Gut, whoſe Exit is near the Neck, where it was firſt taken in.

The Body of this Animal conſiſts of three Parts or Diviſions, in the uppermoſt whereof all the aforementioned Inteſtines are contained, though they are not to be diſtinguiſhed when the Creature is hungry; but after it has eaten they become diſtended and opake, and may very plainly be diſcovered. The other two Diviſions (the lowermoſt of which I take to be fixed to the Bell or outward Caſe) ſeem of no other Service than to give the Creature Power of Contraction and Extenſion.

The Arms ſeem not able like thoſe of the common *Polype* to contract or ſhorten themſelves; but inſtead thereof, when the Animal retires into his Caſe, they are brought together in a cloſe and curious Order, ſo as eaſily to be drawn in. Their general Figure when expanded is that of a Cup, whoſe Baſe and Top are of an *Horſe-ſhoe* Form; but they preſent ſometimes a very different Appearance, by ſeparating into four Parts, and ranging themſelves in ſuch Sort as to repreſent four ſeparate Plumes of Feathers.—*See fig.* 22.

I could never diſcover any Eyes they have, and yet find ſome Reaſon to believe they ſee: for on being ſet in the Light of the

Sun, or a Candle, or brought out of the Dark into the Day-light, though contracted before and retired into the Bell, (as indeed they generally are when in the Dark) they conſtantly extend their Arms for Prey, and ſhew evident Signs of being pleaſed.

Beſides the particular and ſeparate Motion each of theſe Creatures is able to exert within its own Caſe and independent of the reſt, the *whole Colony* has together a Power of altering the Poſition, or even of removing from one Place to another the Bell or common Habitation of them all. Hence this Bell is ſeems ſometimes ſtanding perfectly upright, (as *fig.* 15 and 17.) ſometimes bending the upper Part downwards (as *fig.* 16.)

It has been mentioned already, that between ten and fifteen of theſe Animals dwell together, as it were a little Community, in one Bell-like Caſe or common Habitation: but their Number increaſing, this Bell may be obſerved to ſplit gradually, beginning from about the Middle of the upper or anterior Extremity, and proceeding downward towards the Bottom, till they ſeparate at laſt intirely, and form two compleat Colonies, independent of each other; one of which ſometimes removes itſelf to another Part of the Veſſel. The Manner how the ſingle Animals propagate I have never been able perfectly to diſcover, though there is ſome Reaſon to conjecture it may be by the

Means of Eggs; as ſmall opake Bodies of a conſtant and determinate Figure are ſometimes ſeen lying in their Bells: and unleſs they are Eggs I know not what to make of them. Their Shape is nearly that of a Weaver's Shuttle, being compoſed of two circular Arcs, whoſe concave Parts are towards each other. The Breadth is about two Thirds of the Length, and in the Middle of each a circular Spot appears more opake than the reſt, which poſſibly may be the Embrio. But as I never ſaw any of them come to Perfection, I can make no farther Judgment of them than what their Situation and Form ſuggeſts. They are repreſented *fig.* 15. *a.*

The Bells, or Colonies of theſe Animals, are to be found adhering to the large Leaves of *Duckweed* and other Water Plants; and may eaſieſt be diſcovered, by letting a Quantity of Water, with Duckweed in it, ſtand quietly for three or four Hours in Glaſs Veſſels, in ſome Window, or other Place where a ſtrong Light comes: for then, if any are about the *Duckweed*, they will be found, on careful Inſpection, extending themſelves out of their Caſes, ſpreading their Plumes, and making an elegant Appearance.

They are extremely tender, and require no little Care to preſerve them: their moſt general Diſorder is a Kind of Slime or rather Mouldineſs, which will ſometimes envelope,

velope them in ſuch a Manner as to prove mortal. The beſt Way of curing this is, by gently pouring a large Quantity of Water (perhaps two or three Quarts) into the Veſſel where they are kept, and letting it run off ſlowly: by which Means the Slimineſs will gradually be looſened and carried away with the Water.

As to Food, if freſh Water be given them daily, they will find ſufficient for themſelves; and it is dangerous to try any other Way of feeding them, for the ſmalleſt Worms, or other viſible Inſects one can think of giving them, will tear their delicate Frame in Pieces.

Fig. 15. repreſents one compleat Colony or Bell, ſtanding erect, with all the Animals out of their Caſes, and their Arms extended for Prey; exhibiting all together a very pretty Appearance. Here *a* ſhews the opake Bodies ſuppoſed to be Eggs.

Fig. 16. ſhews all the Creatures withdrawn into their Cells, and the End of the Bell inclining downwards.

Fig. 17. the Bell erect, with only one of the Animals coming out, in order to ſhew its connection with the Bell.

Fig. 18. repreſents a Colony dividing.

Fig. 19. one compleat Animal, greatly magnified, to ſhew its ſeveral Parts more diſtinctly. *Viz.*

a, the Horſe-ſhoe-figured Head.

b, *b*, the Arms ſeen from one Side.

c, the

c, the narrow Neck.

d, the Oeſophagus.

e, the Stomach.

f, the Gut or laſt Inteſtine, through which the Food paſſes, after being digeſted in the Stomach.

g, the Anus, where the Fæces are diſcharged in little Pellets.

h, *i*, that Part of the Bell which ſurrounds the Body of the Animal, and cloſes upon it when it retires down.

Fig. 20. The Head and Arms ſeen in Front.

Fig. 21. The Head and Arms cloſing together, and diſpoſing themſelves in order to be drawn down into the Bell.

Fig. 22. The Arms arranged in a Feather-like Appearance.

CHAP. XI.

The SATYR.

I Frequently have taken notice, in ſeveral Infuſions of Vegetables, of a little cruſtaceous Animalcule, whoſe Picture is given *fig.* 25th of this ſame *Plate* XII. The Shell of this Creature is ſo exceedingly tranſparent, that unleſs great Attention be given it cannot be diſcerned at all. It ſeems to cover the Back only of the Animal: its Belly,

ly, and under Parts, appearing to have no Shell. The Middle of the Body, containing the Bowels, (whoſe periſtaltic Motion may be diſcerned) is ſomewhat opake, and in the Shape of a Bottle with the Mouth downwards; the Sides are tranſparent, and ſhew many Veſſels running through them. Four Legs, or Fins, divided near half their Length, and ſerving either to walk or ſwim, iſſue from the opake Part, and reach beyond the Edges of the Shell: and two thicker and ſhorter Limbs, pointing directly forwards, each of them armed with a ſharp Claw, are placed at the Head-End, and probably are the Inſtruments wherewith it takes its Prey. On each Side of the narrow Part of the opake Body, at ſome little Diſtance therefrom, one ſees a round black Spot, the Uſe whereof I don't pretend to gueſs.—This Animal is briſk and vigorous, ſwimming ſometimes with great Swiftneſs through the Water, at other Times it creeps along at the Bottom of the Drop, and now and then ſkips nimbly like a Flea. It often ſhews itſelf in Profil, as repreſented *fig.* 23.

Monſieur *Joblot* (whoſe Imagination has frequently exaggerated the Figures of Animalcules to be found in Water,) tells us, that he once diſcovered, in an Infuſion of the *Anemony*, an Animalcule having on its Back a Maſk or exact Repreſentation of a *Satyr*'s *Face*; and he gives a Picture ſuitable to that Idea.

Idea. But, making a conſiderable Allowance for the Fruitfulneſs of his or his Painter's Fancy, I think it not unlikely, that the Subject we are treating of might have been the little Animal he ſaw: for the two black Spots, with the Part of the Bowels that comes between them, have ſome Reſemblance of a Noſe and Eyes; the two Points, which terminate the Shell at the Tail-End, appear ſomething like a piqued Beard; the Diſtance between may paſs for a Month, and the Whole put together, might by a true Lover of the *Wonderful*, be worked up to the extravagant Likeneſs of a *Satyr*'s *Face*.—But this is mentioned only by the by, and as a Reaſon why I give it the Name of *Satyr*.

CHAP. XII.

Three AQUATIC ANIMALS *deſcribed.*

TOWARDS the End of *September*, in the Year 1743, ſome Water taken from a Ditch at *Tooting* in *Surry*, (wherein many *Polypes* of an exceeding ſmall Kind had been diſcovered, by my worthy, inquiſitive, and obliging Friend the Rev. Dr. *Henry Miles*, F. R. S.) was ſent to me in a Phial, in order to be examined. And whilſt I was viewing the *Polypes* with the Microſcope, I had

had the Pleaſure of finding three different minute aquatic Animals, which I had never before obſerved.

The firſt of theſe ſeemed to the naked Eye like a very ſmall and ſlender Worm, of about one Third of an Inch in Length: but the Microſcope ſoon ſhewed its real Form and the Singularity of its ſeveral Parts, in the Manner they are repreſented *Plate* XII. *fig.* 24.

From the Fore-part of the Head of this Animal a long *Proboſcis*, *Horn*, or Snout was extended, moving itſelf every Way with great Readineſs, and iſſuing from that Part of the Head where the Mouth ſhould be; which anterior Part changed its Appearance according to the Motions of the Inſtrument, ſometimes extending itſelf and becoming more ſlender, and at other times ſhortening itſelf and growing thicker. About the Head it had ſomewhat of a yellowiſh Colour, but all the reſt of it was throughout perfectly colourleſs and tranſparent, except the Inteſtines, which were conſiderably opake, and diſpoſed as in the Picture. In them alſo a periſtaltic or internal Motion was diſtinctly viſible. Along its Sides were ſeveral *Papillæ* with long Hairs growing from them: its Tail ended very bluntly: it had two black Eyes, and was extremely nimble.

I found only this ſingle Animal of its Kind, from which I drew up the above Remarks

marks at the Time of viewing it, when its Figure was likewiſe carefully taken; but ſoon after I had the Favour of a better Account in a Letter from Dr. *Miles*, who had Plenty of them under his Inſpection: and this I ſhall lay before the Reader in the Doctor's own Words.

" The Worm found in the Water in which " I met with the *Polypes* in this Neighbour- " hood is of various Sizes, from about $\frac{1}{40}$ of an " Inch to half an Inch, and about the Thick- " neſs of the Worms we feed the *Polypes* " with. It is tranſparent, excepting in the " Middle where the Gut runs, which the " Fæces make look of a dirty Colour, but it " has no Redneſs as the Worms have, and " for that reaſon might be reckoned a- " mongſt the Inſects which ſome have " erroneouſly called *exanguious*, ſince our " Eyes, aſſiſted by Glaſſes, ſhew them to " have Blood: as I ſhall preſently tell you " this has.

" The Form of it (when magnified I " mean) reſembles in many Particulars ſome " of our Caterpillars that feed on Vegeta- " bles. It is inſected as they are, and it is " hairy: here and there a little Tuft of " Hairs, and in other Places a ſingle Hair " regularly growing out of the Sides, as I " have attempted to repreſent in the Fi- " gure. I ſaw the periſtaltic Motion of " the Gut, and once ſaw it exclude Fæces,

" three

" three or four Clusters together, which re-
" sembled exactly those of our common
" Caterpillars, or of the Silk-worm Cater-
" pillar. But the most remarkable thing
" in this Creature is a kind of *Horn* or *Feeler*
" which it seems to carry in its Mouth, and
" may be just seen by the naked Eye if
" your Water be clear. 'Tis in the larger
" ones about $\frac{1}{10}$ Inch long. This (I know
" not what to call it) it waves to and again
" as it moves in the Water, or when it
" creeps up the Side of the Glass; which
" it does somewhat like a young Leech, but
" without contracting its Body so much, and
" rather in the Manner that Caterpillars do.

" I have not been able to learn, though
" I have viewed it a long Time together,
" whether it gets any Food with this Horn,
" nor can I find whether it be hollow: but
" I am certain 'tis not pointed, but rather
" blunt: nor have I ever seen it contracted
" any thing considerably.—I must not omit
" to tell you, that 'tis a very tender Crea-
" ture; for in taking up the first I viewed
" with a Quill, as we do the *Polypes*, by the
" Side of the Glass, I injured it so much,
" that it was nearly cut in two, and its
" Horn came off, after it had been a little
" while in the Drop of Water upon the
" Slip of Glass. I was glad of this last Ac-
" cident, as it gave me an Opportunity of
" observing the Horn or Feeler in a better

" Manner

" Manner than I could otherwiſe have done; " for hereby it appeared to me to have grown " into the Fore-part of the Head or Mouth, " and to have been placed (as ſome Bones " are) in a Socket, the End next the Head " ſeeming claviculated or clubbed, and con- " ſiderably bigger than the other: the Head " alſo in the Place where this Horn had " been inſerted was left with a Hollow ſuit- " able to ſuch Articulation. I am doubt- " ful whether the Creature can contract this " Horn or not, nor can I tell whether there " be any Communication between it and " the Entrails. I took Notice that in or- " der to wave it about conſiderably it con- " tracted its Head a little, as if to hold it " faſter and have more command of it; and " indeed the Head reſembles a Sort of For- " ceps graſping this Feeler at the thick " End.

" The ſaid Horn or Feeler has no- " thing remarkable in its Texture, but ap- " pears ſmooth and tranſparent, without " any of the Aſperities that we find on the " Arms of the *Polype*. I ſhall only add, " that the Gut runs viſible from the Head " to about $\frac{1}{20}$ of an Inch of the Tail, where " it ends inſenſibly, for without a good " Magnifier you cannot diſcern its *End*, but " it ſeems to be reſolved into the Body of " the Worm. The Tip of the Tail is very " tranſparent, and there I ſaw with great

" Delight

" Delight the Circulation of the Blood in " the Middle, running to the Gut, as it " ſeemed, and loſing itſelf thereat, by reaſon " of its Opacity.—*Quærenda.* What is " the Uſe of this Horn or Feeler? What " Food does the Creature eat? One would " think nothing taken in by the Horn, *if it* " *be hollow*, becauſe the Fæces are ſo groſs: " if not, how does it take its Food? And " what is it in its mature State?"

The ſecond Sort of Animal I diſcovered in this Water was about a Line in Length, having a large Head, with two black Eyes in Sockets conſiderably projecting, and pretty long *Antennæ*. Its Head, Body and Tail, were divided like thoſe of the Bee or Waſp Kind: from the End of the Tail iſſued three long Branches beſet with Hairs, and each appeared ſomewhat like the Stem of a Peacock's Feather: they could ſeparate more or leſs, be brought together, or move in any Direction that ſuited the Conveniency of the Creature. It had ſix Legs, which ſerved either to ſwim or creep, with Claws at the End of each. The Head, Body and Tail were covered all over with a Sort of Hair or Down, and under the Tail were a Couple of moving Parts like Fins, wherewith it ſeemed to guide its Courſe in ſwimming. It was extremely agile.

Plate XIV. N° 7. A. repreſents this Animal as viewed by the Microſcope.

The Tail Part more enlarged, with its under Side turned upwards to ſhew the Fins, and its three Branches diſplayed, is ſhewn at the Letter B.

The third Sort of Animal, whoſe Figure may be ſeen in the ſame *Plate* at M, had an odd Head, flattiſh before, without any Appearance of Eyes: a Body ſomewhat opake, and a Tail that could divide occaſionally. From about the Middle of the Body a very thin Membrane was extended, on each Side, as low as the upper Part of the Cleft in the Tail; this was moveable, very tranſparent, and ſerved as a Fin in ſwimming. It was very minute, and ſwam along with a direct progreſſive Motion, very ſmooth and regular, but not faſt. Sometimes it would change its Figure, and appear ſomewhat crooked and triangular, in the Manner ſhewn at N.

CHAP. XIII.

The GLOBE ANIMAL.

IN the Month of *July* 1745, three Phials full of Water were ſent to me from *Yarmouth*, by Mr. *Joſeph Greenleaf*, having in them ſeveral Kinds of Animalcules unknown to me before. Some of the larger Kinds died in their Paſſage, occaſioned I ſuppoſe by the Jolts they received, and a Deficiency

Deficiency of Air; the Phials being corked close, and too full of Water to leave them Air enough for Respiration. One kind, however, suffered very little, but when examined by the Microscope was perfectly alive and vigorous, and so numerous in one of the Phials, that the Water might be perceived to swarm with them, though their Size was much too small for the naked Eye to distinguish otherwise than as moving Points. They all died with me in two or three Days, but in that Time I had Opportunities enough to examine them, very carefully, and take a Drawing of them. My Friend Mr. *Arderon* of *Norwich* sent me also, towards the End of the same Summer, some little Account with a Drawing of the same Animalcule, of which he had accidentally discovered a single one in a Drop of Water.

Fig. 27. represents this very singular minute Water Animal, as it is seen before the Microscope. Its Form seems exactly globular, having no Appearance of either Head, Tail or Fins. It moves in all Directions, forwards or backwards, up or down, either rolling over and over like a Bowl, spinning horizontally like a Top, or gliding along smoothly without turning itself at all. Sometimes its Motions are slow, at other Times very swift: and when it pleases, it can turn round (as it were upon an Axis) very nimbly, without removing out of its Place. Its

whole Body is tranſparent, except where the circular black Spots are ſhewn in the Picture; of which Spots ſome had ſix or ſeven, ſome one, two, three, four or five, and others none at all. Theſe probably are its Eggs or young ones: but the ſhort Time they were with me, prevented my coming to a Certainty as to this Particular. The Surface of the whole Body appeared in ſome as if all over dotted with little Points, and in others as if granulated like Shagreen: but their more general Appearance was, as if beſet thinly round with ſhort moveable Hairs or Briſtles; and 'tis not improbable all their Motions may be produced by ſome ſuch Inſtruments, performing the Office of Fins.

CHAP. XIV.

Eggs *of the ſmall Freſh-Water Snail, and* Animalcules *adhering to them.*

THE Group of Figures, *Plate* XIII. N° 1. A. repreſents the magnified Appearance of a Congeries of the Spawn or Eggs laid by a *Water Snail:* which Congeries of Eggs, as ſeen by the naked Eye, is ſhewn at the Letter B.

The Parent Snail is exhibited of its natural Bigneſs C 1; its Back upwards toward the Eye, and

Plate XII *pa. 324*

Animalcules

Fig. 1.

Fig. 2.

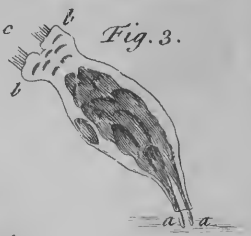


Fig. 3.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 4.

Fig. 5.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 21.

Fig. 22.

Fig. 25.

Fig. 26.

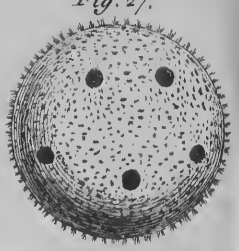


Fig. 27.

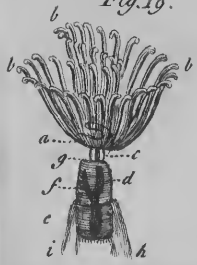


Fig. 19.

Fig. 20.

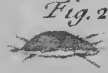


Fig. 23.

Fig. 24.

D E Baker delin.

I. Mynde Sculp.

and its Body extended beyond the Shell, in the Action of creeping from Place to Place.

The ſmall Snail is turned upon its Back C 2; that the true Form and Opening of the Shell may the better be underſtood.

I have frequently kept Numbers of theſe Snails, for many Months together, in a large Glaſs Jar, with Polypes and other Water Animals: and 'tis very common for them to faſten their Spawn, in little Maſſes, againſt the Sides of the Glaſs, where the Eggs hatch in about three Weeks or a Month's Time.

The Spawn, when firſt depoſited, appears to the naked Eye like a tranſparent Jelly; but if examined by the Microſcope, one ſees in it Numbers of ſmall and exceedingly pellucid oval Bodies, at little Diſtances from one another, enveloped in a gelatinous Subſtance; having each of them towards one of its Extremities a very minute dark Speck, wherein, if carefully examined by the greateſt Magnifier, a *Pulſation* may be diſcerned.

This Speck will be found to grow larger from Day to Day, and to become a perfect Snail, with its Shell compleat, ſeveral Days before it burſts through its Integuments. When the Eggs are about a Week old, the *Embrio Snail* may be diſcerned in its true Shape, turning itſelf very frequently within the fine Fluid in which it lies: and the Heart

is then a moſt agreeable and amazing Spectacle, ſhewing itſelf very diſtinctly, and reſembling a little oblong Bladder, much leſs at one End than the other: the *Pulſation* proceeds under the Eye with great Exactneſs and Regularity, and the Syſtole and Diaſtole of this Veſſel are nearly equal to thoſe of the human Heart, ſomewhat more than Sixty *Pulſations* being performed in a Minute, as I have found by ſeveral Trials, keeping my Finger at the ſame Time on my own Pulſe, which uſually beats two or three Strokes more. The Heart is large in Proportion, and may be always ſeen, until the Animal increaſing in Bulk and becoming conſequently more opake, in ſome Poſitions it hardly can be perceived: but as the Animal frequently turns itſelf within the Egg, a little Patience will bring the Heart in full View again; and that as long as the Embrio continues within the Egg. Nay, even after it is hatched, the Heart may be diſcovered for ſome days through the tranſparent Shell †.

The general Plan of Nature is ſo uniform, in the Production of living Animals, though with ſome little Variations as to the Manner of its Execution, that from what we are able to diſcover in the very tranſparent Eggs of

† The ſame Progreſſion I have been deſcribing, was obſerved at *Norwich*, by Mr. *Arderon*, in the *Cornu Ammonis* River Snail.

of this little Creature, ſome reaſonable Conjecture may be formed of what happens in thoſe of much larger Kinds.

According to the uſual Order of Nature, every *Embrio* of an Animal is lodged for a Time within the *Uterus* of the Parent, incloſed in a Caſe or Egg, whoſe outer Coat is either hard and ſhelly, or tough and membranaceous, affording a proper Bed and Covering to preſerve it from external Injury.

In Animals that are *oviparous*, this Egg is excluded out of the Body of the Parent, ſome conſiderable Time before the *Embrio* has attained a Size and Strength ſufficient to endure being expoſed to the open Air without Prejudice: during which Time, it takes in Nouriſhment, and its Limbs acquire a continual Growth, from proper Juices in which it floats, and wherewith the Egg is replete. For the Egg, between the Time of its being laid, and that of its hatching, can receive no other Benefit from the Parent, than what the natural Heat of her Body can afford it: And Experience teaches that the like Degree of Heat, ſupplyed by any other Means, with the ſame Conſtancy, will be of equal Service ‡.

On the contrary, in *viviparous Animals*, the Egg is retained in the *Uterus* of the Parent,

‡ In the Eggs of numberleſs Species, which ſhew no Concern for them after they are once laid, no more Heat at all is neceſſary, than what is common to the Air or Water in which they are expoſed.

rent, till the *Embrio* having attained a certain State of Maturity, endures Confinement no longer, burſts open the Integument, Caſe, or Shell that incloſed it, and iſſues therewith from the Body of the Parent: until which Time the *Embrio* receives its Nouriſhment from the Blood and Juices of the Parent, which are conveyed into the Body of the *Embrio*, by certain Veſſels of the Parent that inoſculate with correſpondent Veſſels of the *Embrio*, and at the Birth become ſeparated therefrom.

Hence it appears probable, that the original Principle of Life, the gradual Expanſion and unfolding of the Members, and the Progreſſion towards Maturity and Birth, are nearly the ſame, whether the *Embrio* be hatched *within* the Body or *without* the Body of its Parent; which ſeems to be the chief Difference between viviparous and oviparous Production. But to proceed.

For ſome Days after the Water Snail has laid its tranſparent Egg, the Microſcopic Speck of Life, wherein the tender Limbs and Rudiments of the Animal are moſt wonderfully folded up and contained, has no other Appearance of Life than only a *languid Pulſation*, but juſt diſcernable by the beſt Glaſſes and the moſt curious Eye. As this Speck increaſes in Bigneſs, it exhibits, gradually, the Figure of a minute Snail, and acquires an Ability of moving itſelf very

ſlowly.

ſlowly. After this, its Size and Motion becomes every Day more conſpicuous, its ſpiral Revolutions ſhew themſelves more diſtinctly, its Form becomes more perfect, a Shell, nnconceivably delicate, is produced over its tender Body: it now occupies a conſiderable Part of the Egg, turns itſelf vigorouſly, and even creeps within it, and in due Time breaks it, and iſſues forth.

'Tis not unlikely this is Nature's conſtant and regular Courſe in the Production of all Creatures that are *oviparous*; and that ſhe proceeds nearly in the ſame Manner to promote the Growth and Birth of the *Embrio* in the Human Race, as well as in all other Creatures that we term *viviparous*, ſeems to me no leſs probable.

After this Digreſſion, which I was inſenſibly led into, I return to take notice, that the Eggs which the Drawing exhibits were about a Fortnight old; at which Time the young Snails were of ſuch Size, in proportion to the whole Room contained within the Eggs, as thoſe marked *c*, *c*, *c*, may pretty nearly ſhew.

The other aquatic Animalcules repreſented as hanging about this Parcel of Eggs, are no other than what were really found adhering to it when it was viewed by the Microſcope: and they were exactly ſituated as in the Picture, which was taken without the leaſt Exaggeration. Their extreme Minute-

neſs rendered them abſolutely inviſible to the Eye, for which reaſon no Attempt is made to ſhew them at the Figure B.

A little Colony of Bell-Animals appear at *d*: their long Tails are faſtened to the gelatinous Subſtance wherein the Eggs are laid; they ſtretch themſelves out, and play vigorouſly in the Water; numberleſs Fibrillæ round the Mouth of each Bell agitating the Water to a conſiderable Diſtance.

More of the ſame Bell-Animals are ſeen at *e*, curling their Tails, in the Manner of a Screw, and pulling themſelves back with a ſudden Jerk, as they conſtantly do when diſcompoſed by any thing. But when all is quiet, they ſlowly extend again in the Water, as far as their Tails permit.——Theſe Bell-Animals are found very frequently adhering to little Bits of Stick, Leaves, Stones, or other Matter that have lain ſome Time in ſtagnant Water, either in the Ditches abroad, or in Glaſſes kept in the Houſe with Infuſions or Water-Animals: and their Motions are very entertaining *. Many of them are ſometimes ſeen adhering by their Tails to one another.

On both Sides this Parcel of Snail's Eggs are ſhewn, in different Attitudes, ſeveral little Creatures, of a Kind which I have been uſed to call the *Funnel-Animal*. They faſten by their Tails to whatever comes in their Way,

* Vid. Microſcope made eaſy, p. 91.

Way, and then opening their anterior End, exhibit a wide Mouth ſomewhat of a Funnel Form, though not compleatly round, but having a Sort of Slit or Gap that interrupts the Circle. The Lips or Edges of this Opening are furniſhed with Multitudes of little Fibrillæ, which by their brisk and continual Motions excite a Current of Water, bringing with it abundance of minute Particles of Matter and living Animalcules, which they ſwallow greedily.—One of them in the Poſture above deſcribed may be ſeen at the Letter *f*.——They can faſhion this Mouth or Opening into the ſeveral Appearances ſhewn in the Picture.

If any thing touches or approaches very near them, they ſhrink back and contract, as at the Letter *g*.

Theſe *Funnel-Animals* never keep together in Cluſters, but live ſeparately and independent of one another, ſwimming freely through the Water, ſeemingly in ſearch of Prey, and after a while fix themſelves to any thing they meet with.

Mr. *De Reaumur* and Mr. *Trembley* diſtinguiſh the little Creatures I have been deſcribing by the Name of * *Tunnel-like Polypi:* and the laſt mentioned Gentleman, to whoſe inde-

* I have not the leaſt Objection to this Name, though I here retain what I had given them myſelf long before either of theſe Gentlemen had publiſhed theirs: and I am pleaſed to find our Ideas of this Creature ſo near alike.

indefatigable Induſtry we are ſo greatly obliged for many curious Diſcoveries of ſeveral Kinds of what he calls *Polypi*, has, by the Help of an ingenious † Contrivance to fix the Magnifiers of his Microſcope cloſe to the Glaſs Veſſels where he keeps theſe Creatures, found Means to obſerve the very extraordinary Manner of their Increaſe; which I ſhall take the Liberty to preſent the Reader, from the Account given by himſelf to the *Royal Society*, and printed in the *Philoſophical Tranſactions*, N° 474.

" Theſe *Tunnel-like Polypi* do alſo multiply by dividing themſelves into two, but " they divide themſelves otherwiſe than the " *Cluſtering Polypi:* they neither divide longitudinally, nor tranſverſly, but ſloping " and diagonal-wiſe. Of two *Tunnel-like* " *Polypi*, juſt produced by the Diviſion of " one, the firſt has the old Head, and a new " poſterior End; and the other the old poſterior End, with a new Head.

" I ſhall call that which has the old Head, " *Superior Polypus*; and that which has " the new Head, the *Inferior* one.

" The firſt Particulars obſervable in a " *Tunnel-like Polypus* that is going to divide, " are the Lips of the *Inferior Polypus*; I mean " thoſe tranſparent Edges that are ſo conſpicuous

† A Deſcription of the Apparatus here referred to, is given by Mr. *Trembley*, N° 484. of the *Phil. Tranſ.* and a Figure explanatory of the ſame may be ſeen Tab. I. *fig.* 4. belonging to that *Tranſaction*.

" ſpicuous in the *Polypi* when entirely
" formed. Theſe new Lips firſt diſcover
" themſelves upon the *Polypus* that is go-
" ing to divide, from a little below the old
" Lips, to about two thirds of the Length
" of the *Polypus*, reckoning from the Head:
" but theſe new Lips are not diſpoſed in a
" ſtrait Line, according to the Length of
" the *Polypus*, but run ſloping near half
" way round about. Theſe Lips are known
" by the Motion in them, but which Motion
" is at firſt very ſlow. That Portion of the
" Body of the *Polypus*, that is bounded
" by theſe new Lips, then gathers up it-
" ſelf: the new Lips inſenſibly draw toge-
" ther and cloſe; whereby there forms
" itſelf, at the Side of the *Polypus*, a Swell-
" ing, that is ſoon found to be the Head
" of the new one, bounded by the new
" Lips firſt diſcovered. Before this Swell-
" ing is grown very remarkable, one begins
" to diſtinguiſh the two *Polypi* which are
" forming themſelves; and when that Swell-
" ing is conſiderably increaſed, the two *Po-*
" *lypi* will be diſcovered, no longer joined
" but by a ſmall Portion to each other. The
" *Superior Polypus* no longer adheres to the
" *Inferior one*, but by its poſterior Extremi-
" ty, which is ſtill fixed on one Side of the
" *Inferior Polypus*: the *Superior Polypus*
" then begins to make Motions that ſeem-
" ingly tend to the ſeparating of him from

" the

" the other; and in a little time he becomes
" quite detached, ſwims away, and fixes
" himſelf elſewhere.— I have ſeen one come
" and fix at the Side of the *Inferior Polypus*,
" from which he was juſt before ſeparated.
" The *Inferior Polypus* remains fixed in the
" ſame Place, where the *Polypus* was, that
" is now divided, and of which he was only
" the half, before the Diviſion took place."

The little oval Bodies at *h*, were inveloped in the ſlimy Matter of the Snail's Eggs: they appeared ſomewhat opake, but without Motion, and were probably the *Aureliæ* of ſome Water Inſects.

CHAP. XV.

Of CLUSTERING POLYPES.

BEFORE the Reader enters on this Chapter, let me adviſe him to caſt his Eye with a little Attention on *Plate* XIII. N° 4, 6, 10 and 13, which will prepare him to underſtand more perfectly the Account of what are here termed the *Cluſtering Polypes*, a Name I call theſe little Creatures by, in Conformity to Mr. *De Reaumur* and Mr. *Trembley*, who have given that Appellation to all the different Kinds of Animalcules that are found hanging together in the Water, after the like Manner.

During

During all the Spring and Summer Seaſons, but eſpecially in the Months of *April* and *May*, great Abundance of theſe, of different Species, are to be found on the Shells or Eggs of Water Snails, on the Leaves of *Duckweed* and other Water-Plants, on little floating Sticks, Straws, or whatever elſe lie upon or near the Surface of ſtagnant Ditches or Ponds, for they don't chuſe to be at any great Depth in Water. The Reaſon they have been but lately and ſo little taken notice of, is, I apprehend, their extreme Minuteneſs, which renders them inviſible, unleſs by a very good Light, and with Glaſſes that magnify conſiderably: at the ſame Time an Area, ſufficient to take in their whole Groups or Branches, muſt come in View, or elſe no Idea can be formed of them; and we know, 'tis not many Years, that *Microſcopes* have been ſo far improved, as to command a large and well illuminated Area by Glaſſes that magnify much, or to have proper Conveniencies for examining Objects even in a ſingle Drop of Water.

Through all the different Species of this Kind of Animal, there is an Analogy or Uniformity, as to the general Figure of their Cluſters or Colonies. Each Colony ſeems conſtantly to ariſe from one Stem or Stalk, which is always affixt to ſome extraneous Body: This Stem divides into a Couple of ſmaller ones, each of which ſubdivides into

to another Pair, and thoſe branch themſelves out again, in the ſame Manner, till the Cluſter is compleated. The Extremities or Heads of the ſmall Stalks are the Bodies of the Animals, in the Differences of whoſe Figure conſiſts the Variety of the Species. Being ſituated in this Order round the common Stem at different Heights and Diſtances, they make a very pretty Appearance, when extended in the Water; not ill reſembling a Noſegay of Cowſlips, or ſome ſuch Kind of Flowers. And one would imagine the ſeveral Heads and their Pedicles to proceed from one common Stem, as the Branches and Flowers of a Plant do from one common Trunk; but a contrary Progreſſion takes place here: for in a Plant the Trunk produces Branches, and thoſe Branches again produce Flowers; whereas the Head here is prior to the Pedicle, and the Pedicle to the main Stem, as will by and by be ſhewn.

The Heads, or little Animals, (of which Multitudes ſometimes are dependent from one Stem,) open their anterior Ends, and play about very briskly in the Water, as far as their reſpective Pedicles will permit; but every now and then, one or other of them ſprings back with a ſudden Contraction, which probably may be when it has catched ſomething that it retires to eat: for this they do when nothing at all offends them; but if they are made uneaſy, by ſhaking the Water,

Water, or touching them with any foreign Body, both Stem and Branches inſtantly contract together, and extend not again till every thing is perfectly at reſt.

But though they are found thus conjoyned in Colonies, each Head is a perfect Animal, and can detach itſelf from the reſt, live ſeparately, and become the Parent of a new Colony, as moſt of them do after a certain Time. All of the ſame Community act after one common Law, in contracting or extending the main Stem as well as their reſpective Pedicles at the ſame Time, though each can contract or ſtretch itſelf out at Pleaſure, without the Concurrence of the reſt, as far as the Extent of its own Pedicle. When a whole Colony contracts together, the main Stem ſeems to pull back the ſeveral Pedicles, and thoſe Pedicles the little Animals at their Extremities: but here the Truth is contrary to the Appearance, for the Animals themſelves begin the Motion that pulls them back, by a ſudden Endeavour to draw up their Pedicles to their Bodies, which Motion the Pedicles communicate to the main Stem, and thereby contract that alſo: Somewhat in the Manner of a Hair, which jerked ſuddenly (not to break) and then let go again, flies back with an elaſtic Force. And that the Caſe is thus ſeems pretty certain, becauſe after one of theſe Animals breaks off from its Pedicle, and leaves the

Colony, the deſerted Pedicle becomes immediately deſtitute of Motion; and when all of them are gone, (as often happens) the Stem and Pedicles, though ſtill adhering as they did before, are unable to move at all.

The main Stem grows large in proportion to the Number of its Branches, which ſometimes are very numerous; ſo that it is probably a Continuation of all the Tails or Pedicles of the little Animals conjoyned together. The Stem and Pedicles look uſually very tranſparent, and like hollow Tubes.

The ſeveral Species of theſe Polypes are nearly alike as to the above Particulars, and differ chiefly in the Length and Size of their little Bodies, and the *Apparatus* wherewith their Mouths are furniſhed.——Amongſt all I have any Knowledge of, no Sort is more common than that repreſented at N° VI. When the little Animals of this Species ſtretch themſelves out and open their anterior Ends, each of them appears of a Bell-faſhioned Figure, with a Kind of Lip turning itſelf outwards round the Rim of the Bell, which Lip is furniſhed with Numbers of *Fibrillæ* that vibrate nimbly in the Water, and cauſe a *Vortex* reaching to a ſurprizing Diſtance, in proportion to the Smallneſs of the Animal: which *Vortex* is ſhewn *a a.*—— When great Plenty of theſe are lodged together on a Snail, Leaf, or other Body, they ſeem of a whitiſh Colour

to

to the naked Eye, but before the *Microſcope* they appear very tranſparent, tho' with ſomewhat of a browniſh Caſt. Their Tails when contracted are drawn back and diſpoſed in ſpiral Lines, like thoſe of the *Bell-Animal* deſcribed *pag.* 330.

The Species whoſe Figure is given N° IV. is much more uncommon.—Its main Stem and Branches reſemble the foregoing, and ſo does the general Figure of its Body, but its Mouth is remarkably different, for inſtead of the very ſmall *Fibrillæ* of the laſt mentioned Species, the Head of this is furniſhed with two large Arms, by the vigorous Motions of which backwards and forwards, a Stream of Water is made to paſs by its Mouth, whereby the Creature is enabled to ſupply itſelf with Food, which is taken in between theſe two Arms. And indeed it is amuſing enough to obſerve the Behaviour and Artifice of this little Creature upon the Occaſion; for as ſoon as the Prey is ſwallowed down it inſtantly retires to the main Stem, by contracting its Pedicle: and by flattening its Body, and bringing the Sides nearly together, it prevents any Poſſibility of the Prey's Eſcape. After it has continued thus contracted for ſome time, it extends itſelf very leiſurely, not unlike the *Bell-Animal:* but in our preſent Subject the Pedicle or Tail when contracted ſeems as if it was ſhrivell'd up, whereas in that it falls back in

ſpiral Lines. The Figures of theſe Animalcules when playing in the Water are ſhewn 2 2: and it is very common, in this and every other Kind of the *Cluſtering Polypes*, for the little Animals either to detach themſelves †, or be broken off by ſome Violence from their Pedicles; the Appearance of ſuch deſerted Pedicles, which have no longer any Motion or Uſe, is repreſented 3 3; and their Appearance is much the ſame in every other Species.

A ſingle Animalcule with its two remarkable Arms is ſhewn, greatly enlarged, at N° v. The Diameter of its Superficies next the Eye being magnified about 400 times, and conſequently the whole ſuperficial Area of one of its Sides (which is all the Eye can command at once) 160000 times; according to which Calculation its Bulk would be magnified 64000000 times.

Thoſe Animalcules of the ſame Species, hanging by their Pedicles, N° VII. are magnified in their Diameter about 40 times, 1600 times in their Superficies next the Eye, and in their Bulk 64000 times.—All the other Species of *Cluſtering Polypes* expreſſed in this Plate are magnified nearly in the ſame Proportion,

† When an Animalcule is ſeparated from its Cluſter, it ſwims about in the Water, until it faſtens its little Pedicle to ſomewhat; and it can detach itſelf again and ſeek ſome other Situation ſo long as it continues ſingle; but after it begins to multiply, the Pedicle never looſens itſelf again, none but ſingle Animalcules being ever ſeen ſwimming.

Proportion, whereby the Reader may form ſome Conception of their Minuteneſs: and yet, ſmall as they are, they are Whales in proportion to the Animalcules they ſwallow down.

N° x. repreſents a Colony of another Species of *Cluſtering Polypes*, two ſingle ones of which magnified in the above Manner are ſhewn N° xi. and N° xii.

Theſe when extended in the Water exhibit a Couple of projecting Parts at their anterior End, furniſhed with Numbers of vibrating *Fibrillæ*, that produce a Current of Water by their quick Motions, and thereby procure them Food. *See* N° xii. —There are ſome with three of the like Projections, &c. *See* N° xi.

N° xiii. ſhews a very extraordinary Species of this Kind of Animalcule, the Body whereof is much longer, its Pedicle ſhorter, and the Connection of the Individuals to each other in the ſame Colony is very different from all the reſt: for here no main Stem is ſeen, but all the Pedicles are joyned in one Center, round which the little Animals extend themſelves circularly, at nearly equal Diſtances, and make a very pretty Appearance. But nothing relating to them is more worthy Notice, than the curious and *wonderful Apparatus* whereby they take their Prey, which the two greatly magnified *Figures* at N° xiv. will aſſiſt the Reader to underſtand the following brief Deſcription of.

The Body of this Animal is very tranſparent, ſeems to be hollow and ſomewhat ſhelly, and is in Diameter at the broadeſt Part, (which is about the Middle Way between its Mouth and Tail) nearly one fifth of its Length: it leſſens from thence towards both Extremities, tapering pretty ſuddenly towards the Tail End, and terminating in a long ſlender Tube near a Quarter of the Animal's Length. Towards the Mouth End it diminiſhes more gradually, and not ſo much, being no where leſs than one half of its greateſt Diameter: it widens again a little about the Mouth, which is quite open like that of a Jug or Pitcher, and ſeems not capable of Contraction, or Dilatation, or furniſhed with any *Wheels* or *Fibrillæ*, as the Mouths of the other Species of the Animalcules are: but to make amends for ſuch Deficiency, it is provided with a moveable *Operculum* or *Cover*, connected to its Body, by a long Ligament or Muſcle, which extending downwards (through the Body or Shell) is affixed within-ſide of it near the Tail. *See a a.*——This Ligament is ſufficiently long to permit the *Operculum* to be lifted up to ſome Diſtance from the Mouth, in which Situation ſix *Fibrillæ* appear placed round the Border of the *Operculum*, at Diſtances nearly equal. (*Vid. b.*) Theſe *Fibrillæ* have a vibrating Motion like thoſe at the Mouths of the other *Cluſtering Polypes*, and ſerve by the Current they ex-

cite in the Water to hurry the Prey into the Mouth of the Animal which ſtands open to receive it; then by ſhutting the *Operculum* down immediately all Eſcape is prevented. After a little while the *Operculum* ir lifted up again leiſurely, and in readineſs for another Capture.

When the *Operculum* is drawn down the *Fibrillæ* are no longer diſcoverable, and the Ligament whereby the opening and ſhutting is performed appears in a flaccid relaxed State, as at *a*.

One of the two magnified Figures in the Plate repreſents the Animal with its Mouth open and the *Cover* up, as it appears when hungry; the other ſhews the *Cover* drawn down after it has ſeized its Prey †.

Having deſcribed theſe ſeveral Sorts of *Cluſtering Polypes*, (and I make no Doubt there are many other Species and Varieties of them unknown to us at preſent) I proceed to conſider their prodigious and ſpeedy Propagation and Increaſe, the Manner whereof is no leſs ſurprizing than all the other Particulars relating to them: and as to this Affair (though I have obſerved them many times myſelf with much Attention) I ſhall chuſe to lay before the Reader what Diſco-

† I never had been ſo lucky myſelf as to meet with this Species of Water Animals, but am obliged to Mr. *Arderon*, (on whoſe Judgment and Fidelity I can depend intirely) for the Figures and Account thereof.

veries the uncommon Diligence and Sagacity of Mr. *Trembley*, who has applied himſelf more than any body to this Enquiry, has been able to produce: for in ſuch extraordinary Caſes 'tis neceſſary to make uſe of all the Evidence one can.

" A ſingle *Polypus* (ſays he) detached " from the Cluſter, ſwims about the Water, " till it meets with ſome proper Body to " fix itſelf upon. It then has a Pedicle, but " which is not longer than the *Polypus* it- " ſelf. In the Space of 24 Hours this Stem " becomes eight or nine times as long as " it was at firſt; and it is this Pedicle which " is to become the main Stem of the new " Cluſter.

" After this the *Polypus* multiplies, that " is to ſay, it divides and ſplits itſelf in- " to two lengthwiſe.— One firſt obſerves " the Lips to be drawn into the Body, whoſe " anterior Part cloſes and becomes round: " the anterior Part of the *Polypus* flats itſelf " afterwards by Degrees, and ſpreads in pro- " portion, becoming broader as it ſhortens; " it then gradually ſplits down through the " Middle, that is, from the Middle of the " Head to the Place where the poſterior " Ends join to the Pedicle: ſo that in a little " while, there appear two ſeparate round " Bodies joyned to the Extremity of the Pe- " dicle that juſt before ſupported but one. " The anterior Part of each of theſe Bo-

" dies

" dies then opens by Degrees, and as they
" open, the Lips of the new *Polypi* ſhew
" themſelves more and more; and, ſoon
" after the Separation is compleated, each
" begins to ſhew a Pedicle of its own.—
" Ten or twelve Hours after, theſe two
" *Polypi* again divide themſelves each into
" two more; they ſoon after put out
" Branches, and thus retire to a greater
" Diſtance from each other.—When two
" *Polypi* are thus formed by the Diviſion of
" one, the one is ordinarily much larger
" than the other: this larger one remains
" at the Extremity of the Branch where it
" was, but which Branch lengthens itſelf
" more, whilſt the other puts out a new
" Branch which ſeems to proceed from the
" firſt. The larger of theſe *Polypi* again
" divides itſelf generally before the other:
" and all I have been deſcribing is reiterated
" ſeveral times. Thus a principal Branch
" is formed, provided with ſeveral lateral
" ones: theſe lateral Branches become
" principal, with regard to thoſe which in
" their turn ſeem to ſpring from them, when
" the *Polypi* at their Extremities come to
" divide.--- All the *Polypi* of a Cluſter do
" not detach themſelves from it at the ſame
" Time: thoſe which are neareſt to the
" Origin of the Branches uſually detach
" themſelves firſt. And every *Polypus* ſo
" detached, goes and fixes itſelf elſewhere;
" every one thus becoming at laſt, if not

" pre-

" not prevented, the Principal of a new " Cluſter.

Mr. *Trembley* tells us farther, " that he " followed the Progreſs of a Cluſter in the " Month of *September* 1744.--- It conſiſted, " on the 9th Day of that Month, but of one " ſingle *Polypus:* this *Polypus* divided itſelf " that Evening, and at Half an Hour after " Eight of the Clock, there were to be diſco- " vered two perfect *Polypi*, whoſe Pedicles " or Branches continued lengthening till " the Morning of the next Day, being the " Tenth of the ſame Month of *September*. " At about a Quarter after Nine that Morn- " ing, theſe two *Polypi* began alſo each to " divide, ſo that after a Quarter paſt Eleven " there were four compleat *Polypi*, whoſe " ſeveral Pedicles formed themſelves ſoon " after. On the Eleventh of the ſame *Sep-* " *tember*, about Half an Hour after Seven in " the Morning, he found that theſe four laſt " *Polypi* had already again divided them- " ſelves, that is to ſay, there were Eight " diſtinct *Polypi*.--- And he has taken No- " tice of Cluſters, the Numbers of whoſe " *Polypi* have conſtantly gone on doubling, " from 2 to 4, from 4 to 8, from 8 to 16, " from 16 to 32: after which he has been " no longer able to count exactly the Num- " ber of the *Polypi*." --- But their Multipli- cation is ſo prodigious, that he ſays, " on " *November* 1ſt. 1744, there was in one of " his Glaſſes, a Cluſter compoſed of ſeveral " leſſer

" leſſer united Cluſters, which was above " an Inch over every Way.'

Theſe Quotatiions are taken partly from N° 474 of the *Phil. Tranſ.* and partly from the *Appendix* to the 44th *Vol.* of the ſaid *Tranſactions*. The *Polypes* here particularly intended, are thoſe I have called *Bell-Animals* in the former Part of this Work, and that *Species* whoſe Figure is given in this *Plate* N° VI. and its Deſcription *pag.* 338. There is however Reaſon to believe, that all the other *Cluſtering Polypes* already taken notice of in this *Plate*, may be propagated after the ſame Manner.

N° VII. VIII. IX. ſhew different Appearances of the ſame Animalcule, which is another Species of the *Funnel-Animal*, *vid.* N° 1, *f g*. They are found together ſometimes in vaſt Abundance on the Shells of Water Snails, *&c.* ſeeming to the naked Eye like a green ſlimy Matter. When firſt applyed to the Microſcope they are uſually ſeen contracted, as N° VIII. but being left at quiet for a little while, they change their Figure to that of N° VII. and ſwim about very briſkly with their large Ends forward. At other Times they appear like N° IX. having then a toothed Wheel at the Head or largeſt End, that moves round with prodigious Velocity, in the Manner of the Wheels of the *Wheel-Animal*, already deſcribed *pag.* 269, but having a much larger Wheel than either of thoſe

thoſe the Wheel Animal is furniſhed with. Its Gyrations are ſo ſwift, that without great Attention they can not be ſeen. The Teeth are moſt conſpicuous when it begins or ends its whirling, or when it becomes ſick by Confinement in a Drop of Water. On being diſturbed by any thing, they contract themſelves as at N° VIII.

CHAP. XVI.

The MULBERRY INSECT.

THE Figures and Deſcription of N° XV. 1, 2, 3, were ſent me by Mr. *Arderon*, in *March* 1745-6.—He ſays, that on the firſt Day of the ſaid Month he found in the Water of a Ditch, at *Norwich*, ſome exceeding ſtrange Animalcules, which from their bearing ſome Reſemblance to the Faſhion of that Fruit, he calls *Mulberry Inſects:* though the little Protuberances that ſtand out round them, equally on every Side, make them rather more globular. Their Bowl-like Motions are much the ſame as thoſe of the *Globe Animal*, deſcribed *pag.* 322; but they did not move ſo readily from Place to Place, and their Protuberances appeared ſo looſely connected together, he ſhould rather take them for a Congeries of Animalcules than one ſingle Animal.—As to this Particular he

he ſeems however in ſome Kind of Doubt: and in a Letter received from him afterwards, he imagines the *Mulberry Inſect* may poſſibly be the laſt mentioned *Cluſtering Polypes* with *Opercula*, (N° XIII.) not yet come to their perfect State. He met with ſeveral of theſe Inſects, or Congeries of Inſects, of different Sizes, and with different Numbers of Knobs or Protuberances, ſome having 50 or 60, others more or leſs even down to 4 or 5, but the Manner of moving was the ſame in all.

CHAP. XVII.

The PIPE ANIMAL.

UPON the Sea-ſhore, on the Coaſt of *Norfolk*, and without Doubt in other Places, Heaps of ſandy Matter are to be ſeen at Low Water, two or three Feet ſometimes in length, compoſing Multitudes of ſmall Tubes or Pipes, which are the Caſes or Habitations of living Creatures. My *Norwich* Correſpondent, to whom I ſtand obliged for this Information, wrote me Word, that a Friend of his broke off and brought to him a ſmall Piece of ſuch a Congeries of Tubes or Pipes, in Shape and Size as at N° II. in which *a a a a* ſhew the Mouths or Openings of the Pipes wherein the little Creatures make their abode.

He

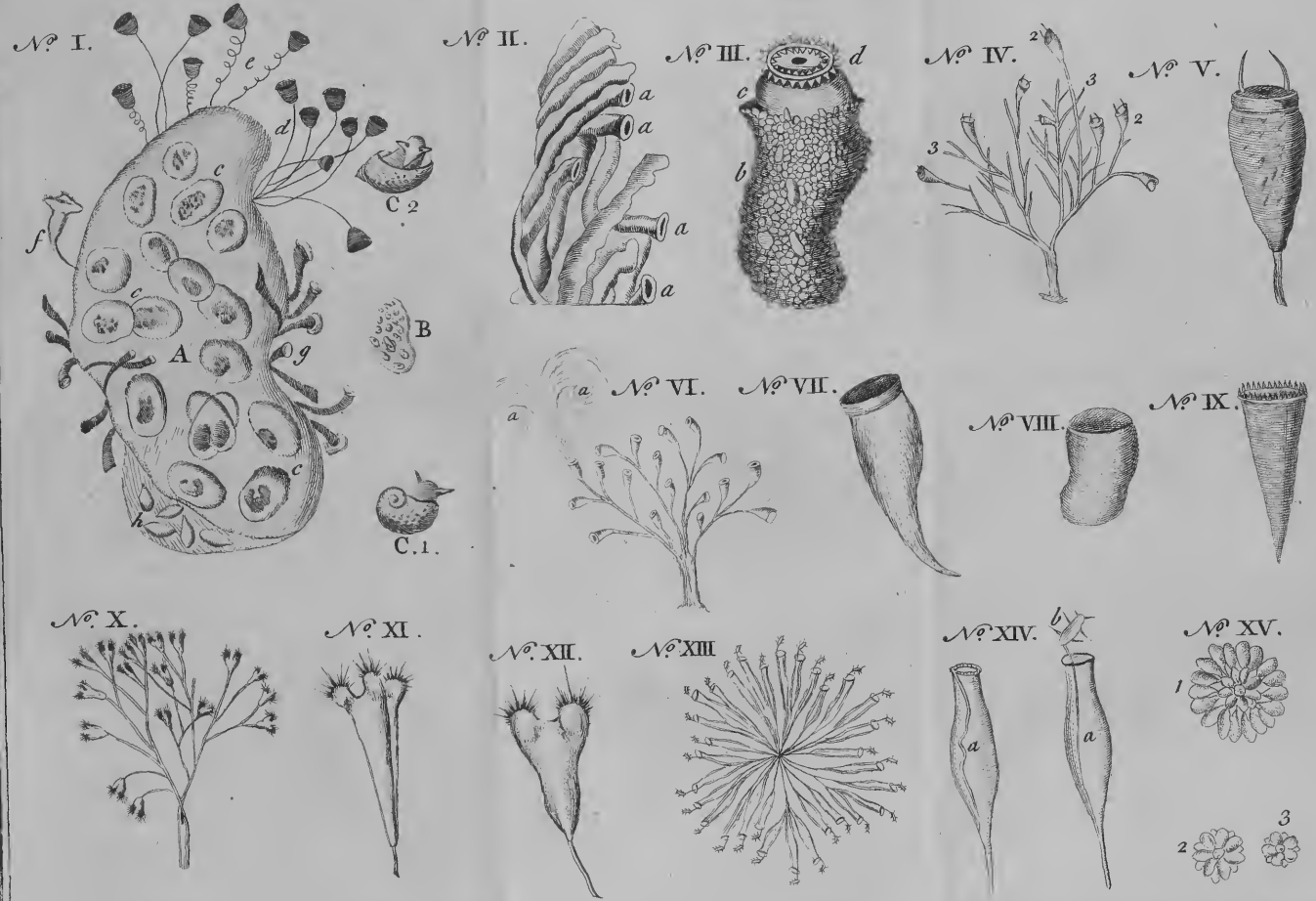
He carefully ſeparated one ſingle Pipe from the reſt, and placed it in a Glaſs of Water, to give the little Inhabitant an Opportunity of coming to the Mouth of its Cell, which it did accordingly very ſoon, and then appeared as at N° III. where the Figures both of the Animal and its Caſe are magnified nine or ten times in Diameter.—The Pipe or Caſe *b* is made of Sand, intermixed here and there with minute Shells and Sand, all cemented together by a glutinous Slime iſſuing I ſuppoſe from the Animal's own Body *c*, which is compoſed of muſcular Ringlets, (like thoſe of a Worm,) capable of great Extenſion or Contraction. The anterior End or Head *d* is exceedingly beautiful, having round it a double Row of little Arms, diſpoſed in very regular Order, and able I ſuppoſe to extend themſelves for the catching of its Prey, and conveying it to the Mouth that appears in the Middle of this anterior End. But the Animal being ſick for Want of Salt Water did not extend its Arms at all, and expiring ſoon after, no Way was left of coming at its true Figure when ſtretched out.

I am ſenſible that the Account here given is very imperfect; but it may I hope induce ſome curious Body, who lives near the Sea-Shore, and has an Opportunity of ſo doing, to furniſh us with a better.

Pipes

Plate XIII. *pa. 350.*

Animalcules.



Pipes or Tubes of this Size and Figure are ſometimes found petrified, and conſtitute one Species of the *Syringoides*.

CHAP. XVIII.

The Water Hog-Louse or Sow.

THE Animal figured *Plate* XIV. N° 1. although an Aquatic, bears ſo near a Reſemblance in its general Appearance to the Millepedes, Sow or Hog-Louſe, eſpecially when creeping at the Bottom of any Veſſel wherein it is kept, that it may properly enough be called a Water Sow, or Water Hog-Louſe.

Its whole Length is made up of nine Diviſions, the anterior and poſterior whereof are the Head and Tail. To the Head, which is almoſt round, and about the $\frac{1}{12}$ Part of the Animal's Length, are affix'd two very long *Antennæ*, each conſiſting, next the Head, of four diſtinct Joynts, and then ſhooting out a Part extremely ſlender and tapering, and but little ſhorter than the whole Body of the Animal; which on a cloſe Examination appears compoſed of many Articulations, having an exceeding fine Briſtle iſſuing from each, as the larger Joynts near the Head have; from the Inſertion of the ſecond of which larger Joynts a Branch ariſes, conſiſting

ſiſting of one Joynt, and a ſlender tapering Part articulated and briſtled as the above deſcribed, but of no great Length. This is ſhewn in the Figures, I, II, III. In the Middle of the anterior Part of the Head are placed two very ſmall and ſhort Feelers. Its Eyes, if it has any (which I think its Actions leave no room to doubt) are not diſcoverable; either from their Smallneſs or the Opakeneſs of the Animal.

The Body (not reckoning the Head and Tail) is compoſed of ſeven Diviſions, which increaſe in their Breadth, but not much in their Length as they approach towards the Tail, the Body being about three times as broad at the laſt of theſe Diviſions as it is at the firſt. From the firſt Diviſion next the Head ariſe two ſhort Claws, terminated by a Hook that can bend down like a Claſp-Knife, and from every one of the other Diviſions proceed two long Legs, each compoſed of five Articulations, and alſo a ſingle Claw at its End. In theſe Legs two Blood-Veſſels may be diſcovered, even by a Glaſs that does not magnify very greatly: one carrying the Blood *from* and the other returning it *to* the Body. The Globules of this Blood, or animal Fluid, appear about ten times as large as thoſe of the human Blood, and their progreſſive Motion is very ſlow and languid, whereby they become more diſtinguiſhable than the Globules are in the Blood of Animals whoſe

whoſe Circulation is ſwifter. The Legs are very hairy, eſpecially at the Joynts, and ſo is the whole Body of the Animal, which occaſions it to be frequently ſo covered and entangled with the Dirt and Scurf of the Water, as to prevent its Figure from being truely ſeen.

The Diviſions of the Body are each of them covered on their upper or back Part with a Scale or Cruſt, extending beyond and hiding the Inſertions of the Legs, which however are ſhewn in N° 11, where the Animal is turned on its Back. To the hindermoſt of theſe Diviſions the Tail is fixed, which is perhaps the moſt remarkable Part of the Animal. Its Length is about three times as much as that of the largeſt Diviſion of the Body; its Breadth nearly equal to its Length, but tapering ſuddenly towards the End, like the Tails of ſome of the Beetle Kinds. From the back Part thereof, which is coverrd with a Shell or Cruſt, ariſe two joyned Branches, ſtanding out at an Angle of about 45 Degrees to the Plane they riſe from, each dividing again into two, and having Briſtles like the Legs. The Uſe of theſe Branches is not yet diſcovered.

On the under or Belly Part are placed two Sets of Valves, riſing up and falling down, alternately, in a perpendicular Direction: theſe may probably ſerve for the Purpoſe of Lungs, or as the moveable Coverings of the Gills of

Fiſhes, to breathe through, or regulate ſome of the other animal Functions. And what ſeems to confirm this Opinion is, that on depriving the Animal of them, the Circulation in the Legs ceaſed inſtantly, though the Creatures lived for ſome time afterwards. The Motion of the Valves, however uniform at any one time, is not always of the ſame Quickneſs, being now and then ſo ſlow as nearly to beat Seconds, (when it is viſible, even by the naked Eye, in certain Poſitions of the Animal,) whereas they move at other times with above twice that Velocity. And this ſeems to be nearly in proportion to the Temperature of the Weather, their Motions being always ſloweſt in the coldeſt Seaſons. At *b* N° 111, which is a Profile View of this Creature, the Valves are ſhewn as they appear when moving. Their working up and down continually, renders it difficult to be ſure of the true Figure, or indeed the true Number of them; but there ſeems to be four Pair, which move not all together but alternately. The external Pair ſeems ſtrengthened and ſupported by a Couple of ſtrong joynted Tendons, as is ſhewn at N° 11. *b*.

The natural Size of this Animal when at its full Growth is about three Tenths of an Inch in Length. Its Motion, notwithſtanding the great Number of its Legs, is very ſlow, aukward and unwieldy: and indeed the Length and Slenderneſs of the Legs ſeem to render

render them incapable of ſupporting the Body in the ſame Manner as thoſe of other Animals do: ſo that it more properly may be ſaid to be dragged along by than to be carried on them. This Kind of Motion makes him a very diſagreeable Companion to other aquatic Animals that happen to inhabit the ſame Veſſel with him, which he rather chuſes to trample on and overturn than to move out of his Way for them. He is however as much tormented in his Turn by Funnel Animals, Bell Animals, Wheel Animals, *&c.* which frequently faſten themſelves upon him, in ſuch a Manner as not to be diſengaged by his utmoſt Efforts.

He ſwims ſometimes, or rather climbs to the Top of the Water, by the Help of his Feet, but cannot remain there for any Length of Time, his Weight immediately ſinking him down again: and indeed he generally chuſes to continue at the Bottom, where he frequently is found covered and overwhelmed by the ſlimy Sediment of the Water. He ſometimes alſo brings his Head and Tail together, and forms himſelf into a Ball in the Manner of the Land Hog Louſe.

As to the Way of their Generation, nothing farther is yet diſcovered than that they are viviparous: for they are ſometimes found having a large Bag hanging down from their Bellies, as ſhewn at *a*, N° 111. On cuting this open the young ones have been ſeen

to come out alive, to the Number of ſeventy or eighty: yet on examining the Animal the Day following the Operation, there ſtill appeared ſome remaining in the Bag; but whether they came not all out at firſt, or that ſome of them returned in again, was uncertain, tho' the latter ſeem'd moſt probable. An old one is ſometimes ſeen holding one of its Young, (when grown even to a conſiderable Size,) under its Belly between its Legs, which it will not part with unleſs compelled to do ſo by ſome conſiderable Force.

CHAP. XIX.

Of the Freſh Water SQUILLÆ.

THE Animal whoſe Figure is exhibited N° IV. *Pl.* XIV. was brought to me, amongſt a Variety of other Inſects, in ſome Water taken out of a Pond communicating with a Ditch at *Kentiſh* Town, near *London*. The Head and Breaſt were cruſtaceous: the Tail and Belly Part were ſoft, and except the Inteſtines extremely tranſparent; by which means, the periſtaltic Motion of the Bowels could be ſeen with great Diſtinctneſs. The Head was armed with a pair of ſtrong Forceps, ſerrated or toothed near their Baſe like thoſe of ſome Spiders, whereby they are the better

better enabled to hold their Prey. A pair of hooked Claws were likewiſe placed near the Inſertion of the Forceps, and became aſſiſting to them. A Snout projecting between the Forceps, having two very ſhort Feelers, and between them a ſharp ſlender Proboſcis, could be thruſt out or drawn back at Pleaſure. Under the Breaſt and Belly were ſix Legs, ſerving either to ſwim or crawl. It had two pretty large black Eyes: from the Breaſt to the Extremity of the Tail the Sides were thinly beſet with Briſtles, and a few Briſtles were upon the Legs. The Bowels were ſeen moving, as plainly as if they had been in a tranſparent Caſe, widening their Diameters and riſing upwards towards the Breaſt, and then preſently contracting in width and extending downwards: theſe Motions were alternate; and ſometimes the Bowels were ſtretched almoſt to the End of the Tail, where the Anus was placed, and there diſcharged the Fæces. It was exceedingly voracious, killing and devouring moſt of the other Creatures that were in the Water with it.

I take this Animal to be a Freſh Water *Squilla*, of which there are many Species. It was about twelve times leſs than the Drawing, and therefore muſt either be of a much ſmaller Species than I have ever met with, or elſe a very young one, not yet perhaps come to its perfect State; the Tail be-

ing neither joynted nor ſcaly as the larger are, ſome of which I have ſeen bigger than the Figure before the Reader. I know the *Squillæ* change their Coats ſeveral times, and perhaps they may alſo change their Form.

As the natural Hiſtory of the *Squilla* is known to very few, I ſhall here inſert ſome curious Obſervations made thereon by Mr. *Joſeph Sparſhall*, of *Wells* in *Norfolk*; in a Letter dated *April* 6th 1749.

The following Obſervations (ſays he) were made laſt Summmer, whilſt I lived at *Wymondham*, on an Inſect very common in the ſtanding Waters thereabouts, I think it's the ſame deſcribed by *Mouffet* in his *Theatre of Inſects*, by the Name of the *Squilla Aquatica*. — In ſearching for other Water Inſects, I have frequently found theſe amongſt Weeds in Ponds and Ditches, full two Inches and a half in Length.

The Head of this Animal is broad, flattiſh, and pretty tranſparent, being very thin in the fore Parts. It has no Mouth, nor does it ſeem to need any, for it takes in all its Nouriſhment through a large and ſtrong pair of Forceps, one Limb of which is placed on each Side its Head. Theſe Forceps are hollow almoſt their whole Length, with a very ſmall Aperture on their Inſide; and when the Creature has ſeized its Prey, the Juices are conveyed through the Forceps, by two Channels, to about the Middle of the Head; where both

both Branches unite and are thence continued to the Stomach. I am the more certain of their receiving no Nouriſhment but what paſſes through the Forceps, as I have often by the Aſſiſtance of a ſingle convex Glaſs, and ſometimes by the naked Eye only, when the Inſect has been ſucking its Prey, ſeen the Juices thereof paſs in a fine Stream through the Forceps and Head. This is more particularly viſible juſt after the *Squilla* has caſt its Skin; at which Time the Forceps and Head are moſt of all tranſparent. Six very ſmall black Eyes are diſcernable on each Side of the Head, very near the Origin of the Forceps.

Its Body is compoſed of eleven Joynts or annular Diviſions; the Edges whereof ſlide eaſily over one another: the laſt Diviſion is long, tapering and hollow, ſerving to buoy up the Animal to the Surface of the Water: its Back is hard and of a dark brown Colour, having a paler Streak down the Middle: its Belly is ſoft and yellowiſh: it hath ſix Legs finely beſet on each Side with a ſingle Row of Hairs; its Tail is alſo hairy and divided at the End.

In the Water it generally hangs, ſuſpended by the Tail, from the Surface; the Body arching backwards, ſo as to make the Belly the convex Part, and the Head inclining upwards towards the Back. In this Poſture it waits, like its Fellow-deſtroyer the Croco-

dile, quite motionleſs, till its Prey is fairly within its Reach; when by a ſudden Spring of the Head it ſeizes it in an Inſtant, and ſeldom quits it till it has got its Belly full.

I kept ſeveral of theſe *Squillæ* in Jars during the greateſt Part of laſt Summer, to make Obſervations on their Manner of feeding; in order to which, I began with giving them the larger Sort of Earth-Worms, which they ſeized with the greateſt Eagerneſs; and notwithſtanding the wreathing and twiſting of the Worms for a long Time, they very ſeldom quitted their Hold, till the inward Contents were quite exhauſted, and nothing left but the Skin.

I uſed frequently, for Want of more proper Food, to give them ſmall Pieces of raw Veal or Mutton, which at firſt they were very greedy of, but would not eat for above a Day or two together: but whilſt I have been giving them a Bit of Meat, they would ſtrike at my Fingers with great Fury, though they were not able to penetrate the Skin*.

One Day I offered one of them a very large Tadpole, and quickly diſcover'd it was its natural Food by the Greedineſs with which it

* One of theſe, which I kept ſome time, was ſo bold and furious as to attack any thing that was put into the Water: inſomuch that I uſed frequently to divert my Friends with holding a Quill near it, which it would fly at and ſeize with great Violence, and hanging faſt there to by its Forceps, would ſuffer itſelf to be pulled up quite out of the Water by it.

it ſeized it: and by giving them in large Quantities, I found it would ſometimes deſtroy near twenty of them in a Day, ſucking them till all the Inwards were exhauſted. Another Time I put a Tench of about three Inches long into a Glaſs of Water where one of theſe Creatures was, ſcarce believing it durſt make an Attempt on an Animal ſo ſuperior in Size: but no ſooner did the Tench come near the *Squilla* than he ſtruck at it with all his might, and fixed his Foreceps in its Side; tho' the ſtruggling of the Tench made him quit his hold. A Drop or two of Blood iſſued from the Wound, and the Fiſh died in about a Minute: which makes it not improbable, the Bite of this Creature may be poiſonous to the Inhabitants of the Waters.

The Banſticle itſelf, which is ſo great a Deſtroyer of the ſmall Fry of Fiſh, and ſo well armed for Defence, is notwithſtanding a Prey to this Devourer; as I found by putting a very large one into the Jar where I kept a *Squilla*. This Banſticle had lived about a Month in a Jar amongſt ſome Tench, moſt of which had felt the Effects of his Fury, though three times larger than himſelf. He was always very lively, and would ſeldom ſuffer the Tench to meddle with the Worms I gave them, till his own Belly was full. But on putting him to the *Squilla* he was changed immediately from the moſt daring to the

the moſt fearful Animal; lurking at the Bottom of the Glaſs, and continuing there for ſeveral Hours together; neither would he touch the Worms I offered him, ſeeming perfectly ſenſible of the Power of his Enemy. However at laſt, coming within the Reach of the *Squilla*, it ſeized him furiouſly by the Back, entering its Forceps on each Side, and after a few faint Struggles he yielded to the Conqueror.

Some time after, I put into the ſame Jar two ſmall Water Newts, of about an Inch and half in Length; which were both devoured in a verry little while. I alſo put into the ſame Jar a Water Newt near four Inches in length, imagining the *Squilla* would not venture to attack one of ſo large a Size; and indeed at firſt he ſeemed afraid of it, but in a few Hours ventured to ſtrike at it: though the Skin of its Back being too thick for his Forceps to enter, he made ſeveral unſucceſsful Attacks, till ſeizing it by the Belly he quickly killed it.

Theſe Creatures certainly deſtroy great Numbers of Fiſh, and may poſſibly occaſion the Death of many of thoſe that are frequently ſeen lying dead by the Sides of Ponds, *&c.* yet they ſeem more fond of Tadpoles, and are found very large and plump where there is Plenty of them; but in other Places are generally very ſmall.

I have obſerved another Species of the *Squilla* ſomewhat different from the former: they are conſtantly hunting about in queſt of Prey, ſwimming by the Aſſiſtance of their Legs in an Horizontal Poſition. I put ſeveral of both Sorts into a Jar of Water together, but the firſt deſcribed quickly devoured all the laſt, though ſome of them were nearly of an equal Size †.

CHAP. XX.

The BRISTLED INSECT.

NUMB. v. *Plate* XIV. repreſents a ſmall cruſtaceous Inſect which was found crawling on a Brick Wall, *June* 30th 1746. Its general Appearance was ſomewhat like that of the *Millepes*, *Sow* or *Wood-Louſe*; but beſides its being covered with Briſtles, whereas

† The chief Difference between theſe two Sorts of *Squillæ*, both of which I am acquainted with, conſiſts in the arming of the Head; which in the voracious Species is furniſhed with only a ſtrong hooked Pair of plain ſmooth Forceps, like thoſe of a third Sort ſhewn in this ſame Plate N° xvi, and again more magnified as *fig. S:* but having no Snout between the Forceps as there is at *S.*—The Head of the more gentle Sort is like N° iv, juſt now deſcribed, having ſerrated Forceps, and an additional Pair of Claws, (nay in ſome Species even two Pair of Claws) about the Head to aſſiſt the Forceps: Theſe feed on *Pulices aquatici*, and other ſuch ſmall Inſects, whereas the firſt mentioned Species prey on Worms, Tadpoles, Newts, Fiſhes, &c.

as the *Millepes* is smooth, and its having a pretty long bristly Tail, it infinitely surpassed any of that Kind in Beauty. The Coat or Ground was brown, and on that a great Number of indented Bristles or Spines were set, which on its Sides were disposed in Tufts, but on its Back in Rows. They were of a snowy Whiteness, and made so fine a Contrast to the brown Coat whereon they stood, that the whole, when magnified, resembled a curious Piece of Carving in Lignum Vitæ set off with Decorations of Ivory.

This is a rare Insect, of which I don't remember ever to have met with any Description.

CHAP. XXI.

An Insect with Fish-like Fins.

AMONGST some Water and Weeds brought from a Ditch that communicates with the River *Yar*, a beautiful little Animal was discovered, (*May* 9th 1746,) whose Singularity seems well worth describing: and it is hoped that the Figure N° VI. will give a pretty good Idea of it. The Head was remarkable for two very large pearled Eyes and a Pair of long Antennæ. The anterior Part of its Body had much the Resemblance of some of the Beetle Tribe, and was

was furniſhed like them with ſix ſlender Legs. Immediately below this Part, the Body leſſened, and was connected together by ſeven Articulations, the Part between each Joynt ſpreading wider at the lower than at the upper End. They appeared all together like the Spinal Vertebræ; and from the Proceſs of each Joynt iſſued a Pair of Fins, making ſeven Pair, or fourteen in the whole. Three other Joynts below the Fins terminated the Tail, the End whereof was ornamented with three long and very elegant Briſtles, beſet on every Side with ſhort Hairs, and appearing like Plumes of Feathers. The whole Animal was of a faint green Colour, except the Fins, which were as tranſparent as Cryſtal. Under each Fin ſtood out a ſmall Spine; ſerving either to ſupport the Fin, or as a Weapon of Defence.

Its Motion in the Water was extremely ſwift, darting itſelf along at a ſurprizing Rate: with one Stroke only of its Fins it would ſwim acroſs a Glaſs Jar it was kept in; but out of the Water it creeped as Land Inſects uſually do. Its Legs were never employed whilſt in the Water, and on the Land it makes no uſe at all of its Fins.

This Animal is in its Nympha State, out of which it changes into a ſmall Species of the *Libella* *.

CHAP.

* No. VII. of this Plate was deſcribed pag. 321.

CHAP. XXII.

An Inſect *with* Net-like Arms.

AN inquiſitive Mind will be inexpreſſibly delighted with conſidering the different Forms of living Creatures: the Changes they undergo; their ſeveral Parts, Members and Organs; the manner of their Production; their various Motions, Diſpoſitions and Ways of Life; the different Kinds of Food they eat; their Sagacity, Cunning and Dexterity in procuring it, and the Inſtruments they are furniſhed with for that and every other needful purpoſe. Theſe are Subjects that open the Underſtanding, and unite every Faculty of a well diſpoſed mind to adore the Almighty Author of ſuch amazing Contrivance, Order and Beauty. Every thing that lives can furniſh out an Entertainment of this Sort: but the larger Animals with which we are daily converſant and familiar, though of a more noble Nature, and immediately neceſſary to Man: theſe, I ſay, as to the Particulars abovementioned, have not the ſame Charms of Novelty to gratify Curioſity and recommend them to a ſtrict Examination, as thoſe very minute and almoſt imperceptible Creatures, diſcoverable by Glaſſes only: with any whereof we are hitherto but ſlenderly acquainted, and of which there

may

may be probably thouſands of Species never ſeen by an human Eye.

Amongſt the ſmaller Animals, the little Creature I am about giving an Account of has I believe hitherto eſcaped Obſervation; and might perhaps have ſtill continued long unknown, had it not been diſcovered accidentally, by the ſame ingenious Searcher into Nature, to whom the Reader is obliged for many curious Articles in this Volume, and whoſe Deſcription of it I can depend upon, though I have not met with it myſelf.

In a Letter now lying before me, dated *July* 10th 1746, he writes me word, that on the 25th of the Month of *May* preceding, going to the Seat of *Benjamin Nuthal, Eſq*; at *Framingham*, in *Norfolk*, he had the Pleaſure there of ſeeing ſeveral Caſcades, ſupplyed with Water from the Side of an adjacent Hill, and affording a moſt charming Proſpect: and that as he was there attentively obſerving one of the Conveyances belonging to the Caſcades, through which the Water ran extremely ſwift, he diſcerned at its Bottom ſeveral ſmall Inſects, ſtanding erect upon their Tails, and reſembling when all together the Combs of Bees, at the Time they are filled with their Aureliæ; but on touching them, they immediately ſeparated and diſperſed. However he took up many of them in a Bottle with ſome Water, in order to examine them at Leiſure; and looking at them

them next Morning, he found they had formed a great many *Threads* in the Water, much reſembling the Webs of Spiders: one of them being taken out of the Bottle with a Quill, it dropped therefrom, and ſpun a Thread by which it hung, exactly like the common Garden Spider.

He then examined one of theſe Creatures by a *Microſcope*, and was much ſurprized at the Oddneſs of its Shape, and the very extraordinary Method whereby it takes its Prey.——The Body appeared as if it had been elegantly turned with a Lathe; being curiouſly rounded, and gradually ſwelling and diminiſhing in ſeveral Places; and at the Tail End were three Spines whereon to raiſe itſelf and ſtand upright in the Water; but the moſt amazing Circumſtance of all was the Apparatus about its Head, where there was placed on each ſide a Kind of Fan or Net-like Machine, ſerving to provide its Food. *Vid.* N° VIII. *Plate* XIV.

Theſe Nets (if it may be allowed to call them ſo) the little Animal frequently ſpread out and drew in again: and when drawn up they folded together with the utmoſt Nicety and Exactneſs, and could be brought ſo cloſe to the Body as not to be diſcernable. At the Bottom of theſe Nets or Fans a Couple of Claws were faſtened to the lower Part of the Head; which Claws, every time the Nets were drawn in, conducted to the Mouth of

the

the Animal whatever was taken in them proper for its Food. When the Creature did not employ its Nets, it thrust out a pair of sharp-pointed Horns for its defence, as is shewn at N° IX, where a larger Figure of the Head and Claws is given, the Diameter being there magnified twenty times, and the Area 400.

These curious Animals were all dead in 48 Hours, notwithstanding fresh Water was given them several times; which then prevented any Opportunity of learning more concerning them, and made my Friend imagine they might be amphibious Creatures, tho' he found them in Water; or might possibly undergo some Change in Form, or Way of living, the Discovery whereof he hoped for at some other Season.

He searched for them after this in the same Place several times, but without being able to find any of them, which occasioned him to conclude, they had either put on another Form, or removed themselves to some other Parts of the Water. However he had met with no Opportunity of looking there for them, at or about the Season when he had first observed them, 'till the Year 1749, when happening to be near the Cascades on the 21st of *May*, he determined to try his Luck once more, and then found, with little Trouble, many of the very same Animals, in the most rapid Part of the Cas-

cade where he had ſeen them firſt. He carried ſeveral of them home very carefully in a Phial, but in two Days moſt of them were dead, and the reſt having ſpun themſelves thin tranſparent Caſes, (which were faſtened either to the Sides of the Glaſs, or to Pieces of Graſs put into the Phial with the Water,) became changed into what he ſuppoſes a Kind of Chryſalis, of which a Front-View is given N° XI, and a Side-View N° XII. But before their taking this Form, he perceived them ſometimes in another Shape, different from the firſt deſcribed, and ſuch as is ſhewn N° X; which, he ſays, was the Figure they appeared in, when they were weary with cathing their Prey, or lay in wait for it.

None of them lived more than three Days: and 'tis remarkable, that notwithſtanding freſh Water was give them two or three times a Day, yet in a few Hours it would ſtink to a Degree ſcarce conceivable, and that too at ſeveral Yards Diſtance, tho' in proportion to the Water all the included Inſects were not more than as 1 to 1,150,000. —— How exquiſitely ſubtile and minute muſt the Effluvia from the Bodies of theſe little Animals be, that can ſo ſoon and ſo ſtrongly infect ſuch Quantities of Water and Air? This perhaps makes it neceſſary for them to live in a rapid Stream, leſt they ſhould be poiſoned with their own Perſpiration,

ration, as perhaps they were in the Glass Phial.

The largest of them exceeds not $\frac{2}{10}$ of an Inch in Length and $\frac{1}{30}$ of an Inch in Diameter: they seemed rather soft and fleshy than crustaceous, and their Colour was a Kind of yellowish grey.

CHAP. XXIII.

Insects *found on the Bark of the* Ash.

AT the beginning of *February* 1748-9, I received from the same curious Person two Pieces of the Twigs of an Ash Tree, (just cut when they were sent) of about half an Inch in Diameter. Each of these had one of its Sides covered thickly from End to End with Numbers of little Spots, not larger than very small Pins Heads, and rather long than round. Their Colour was somewhat different from the Bark on which they were placed, and an attentive Eye could perceive they rose a little about it. On crushing them, a Liquor red as Blood issued out; and each Spot, when examined by the *Microscope*, was found to be of a silky Substance, adhering closely to the Bark, and serving as a Covering or Nest to 30 or 40 *Ova*, which on removing this Covering with the Point of a Lancet presented themselves to View; much re-

semblingthe *Aureliæ* of *Ants* in Shape, but a thousand times more minute, and of a beautiful scarlet Colour.

This Discovery excited a strong Desire of learning what kind of Animalcules these little *Ova* would produce; but those in my Possession never came to any thing, being I suppose deprived of a due Degree of Moisture by the Drying of the Twigs. My Friend's Diligence however supplied this Defect: for sticking a Bough covered with them into the Ground, in his Garden, in a warm Corner where the Sun could shine freely upon it, prodigious Swarms were hatched of beautiful little Insects of a fine Scarlet Colour, whose Figure is given N° XIII.--- O.--Their Back is something like that of the *Wood-louse* or *Sow*, and in other Respects they differ not greatly from that Animal in Form: but are armed with a large strong pair of Forceps, which the *Wood-louse* has not.

'Tis a pleasing Entertainment to see them creep out of their silken Cases or Coverings, at an Opening in the Cases at one End, left there probably for that purpose by the Parent Insect, when she wove this Integument over her little Brood to preserve them from Injury; in like Manner as many Sorts of Caterpillars leave Openings, or a much looser Spinning at one End of their Pods, through which after their Change they may be able to come forth. *See* N° XIII.

And it is worth remarking, that every single Insect, besides being inclosed in this Covering of Silk, which is common to 30 or 40 of them, has a pure white transparent Case or Shell, which being left by the Insect nearly resembles the Shape of an Hen's Egg; and if they are not disturbed at the Time of hatching, most of their Egg-shells will be found empty under the common Coverture. And by attending to them a little, one shall see, at the same time, several of these Insects hatched, some just breaking out of their Shells, and others creeping about with their Shells hanging to their Tails, as at N° XIII.

My Friend's Account says, that the largest of these Animalcules measured little more than the 114th Part of an Inch in Length, and the 200th Part of an Inch in Breadth, and consequently the Number of them required to cover a superficial Square Inch would be something more than 22800 *.

His Method of finding their Magnitude was as follows.--- In order (says he) to be certain of the magnifying Power of the Glass I made use of, (which was the third Magnifier) I divided a Line, drawn exactly an Inch in Length on a Slip of round Glass, into 20 equal Parts. Then placing this Slip of Glass under the Microscope, I threw the magnified Image of one of these 20th Parts upon

* This is the least Insect I have observed produced out of the Water.

a Scale of Inches ſeen by the naked Eye, according to Dr. *Hooke*'s Method †) and found it coincide exactly with 4 Inches: and conſequently that the Glaſs magnified 80 Times.

Then taking my divided Inch from under the Magnifier, in order to make uſe of it in the ſame Manner as I before had done of the Scale of Inches, I caſt the magnified Image of one of theſe Animalcules on my Scale of Twentieths of an Inch ſeen only by the naked Eye, and found its Length to cover 14 and its Breadth 8 of thoſe 20th Parts of an Inch. — But the Meaſures of $\frac{14}{20}$ths and $\frac{8}{20}$ths being only the apparent Dimenſions, they muſt be divided by 80, the magnifying Power of the Glaſs, to give the real Size of the Animalcule, which will then be found to be $\frac{14}{1600}$ in Length, and $\frac{8}{1600}$ in Breadth: which Fractions reduced to their ſmalleſt Denominators will be $\frac{7}{800}$ (nearly $\frac{1}{114}$th) and $\frac{1}{200}$: or taken decimally, $\frac{875}{1000000}$th, and $\frac{5}{1000}$th Parts of an Inch.

CHAP. XXIV.

The LOUSE *of the* CARP.

THE Animal ſhewn at N° XIV. *Plate* XIV. was found, with ſeveral others of the ſame Kind, ſticking to a large Carp, juſt

† See this Method explained in *The Microſcope made eaſy*, pag. 45.

juſt taken out of the *Canal* in St. *James's Park*. I was about one Tenth of an Inch long, and nearly as much in Breadth at the broadeſt Place. Its Back was covered with a Shell, (or rather pliable Scale) of the Figure repreſented in the Drawing: this Shell was ſo extremely tranſparent, that the finny Legs, of which it has four Pair, beſides two ſhorter Claws, might be ſeen almoſt as clearly through it as if they had no Covering; and on each Side the Body of the Animal, at equal Diſtances therefrom, were many curious and beautiful Ramifications, ſomewhat opake, extending a conſiderable Length, and ſeeming either to be Blood-veſſels, or muſcular Proceſſes connecting the Body with the Shell.

The Tail was a Kind of ſcaly double Fin, not unlike thoſe at the Extremity of a Lobſter's Tail, but exceedingly tranſparent, and each Half or Fin was marked with one ſingle black Spot, as in the Plate.

The Eyes (which for the Sake of ſhewing them to more advantage are greatly magnified at *fig.* K. 1. 1.) were very ſingular in their Structure, being neither ſmooth ſingle Balls, like thoſe of moſt Quadrupeds, Birds and Fiſhes; nor pearled Balls like the Eyes of many Inſects; but in this Animal each Eye was compoſed of a globular Body, almoſt incircled round with ſmaller Globules, as the Drawing repreſents.

Between the Eyes appeared two pair of ſhort ſtrong Spines, one pair whereof pointed forwards and the other backwards: I know not whether theſe ſerved as Feelers, or were Weapons of Defence or Offence. At a little Diſtance below the Eyes were placed two large cylindrical or rather ſomewhat conic Suckers, compoſed of ſeveral *Annuli*, ſeemingly like thoſe that form the Windpipe in Birds and Beaſts. The Animal, by means of theſe, adheres and fixes itſelf ſo ſtrongly to the Fiſh it preys upon, that all the Motions and Efforts it can uſe are inſufficient to ſhake off the little Tormentor, who is continually feeding on and making it uneaſy. See the Suckers *fig.* K. 2, 2. Juſt below them at 3, and above the grand inteſtinal Duct, lay the Heart, compoſed of two Lobes, which might be ſeen to contract and dilate alternately, as the Hearts of many other minute aquatic Inſects do.

One of the ſhort Fore-claws, which is covered with a ſtrong Shell, and armed with three Hooks at its largeſt Joynt, is ſhewn *fig.* L.

This little Creature makes a very pretty Appearance in the Water, where it is continually playing up and down, with a Kind of hovering Motion, like that of the *May-Fly* in the Air. Sometimes it leaves the Fiſh to divert itſelf for a while in ſuch Manner, and then ſettles on it and fixes itſelf again.

again. The internal Motions of the Bowels, *&c.* are preſented ſo finely to Obſervation, by the uncommon Tranſparency of its Shell and Skin, that it is a moſt agreeable Object for the *Microſcope*; and the Carp is often peſtered with ſuch Numbers of them, that they are not very difficult to procure. They may be kept a long while with the Carp in Water, but unleſs the Fiſh be with them they die in a Day or two.

The natural Size of this Inſect, as its full Growth, is ſomething leſs than one of its Eyes appears in the magnified *fig.* K.

CHAP. XXV.

The Louſe *of the* Banſtickle, *or* Prickleback.

NUMB. xv. is the Picture of the little Vermin that infeſts the *Banſtickle* or *Prickleback*; whereto it adheres ſo firmly that it is hardly poſſible for the Fiſh to get rid of it, unleſs it pleaſes to unfix itſelf. It is furniſhed with a pair of ſucking Inſtruments like the *Carp-louſe*, has the ſame Number of Legs or Fins which are continually in Motion whether it be ſwimming or faſtened upon the Fiſh: and in moſt other Particulars it ſo nearly reſembles the ſaid Animal, that after taking notice of ſome Difference in Shape, which

which the Picture may ſerve to ſhew, nothing more need be ſaid about it.

CHAP. XXVI.

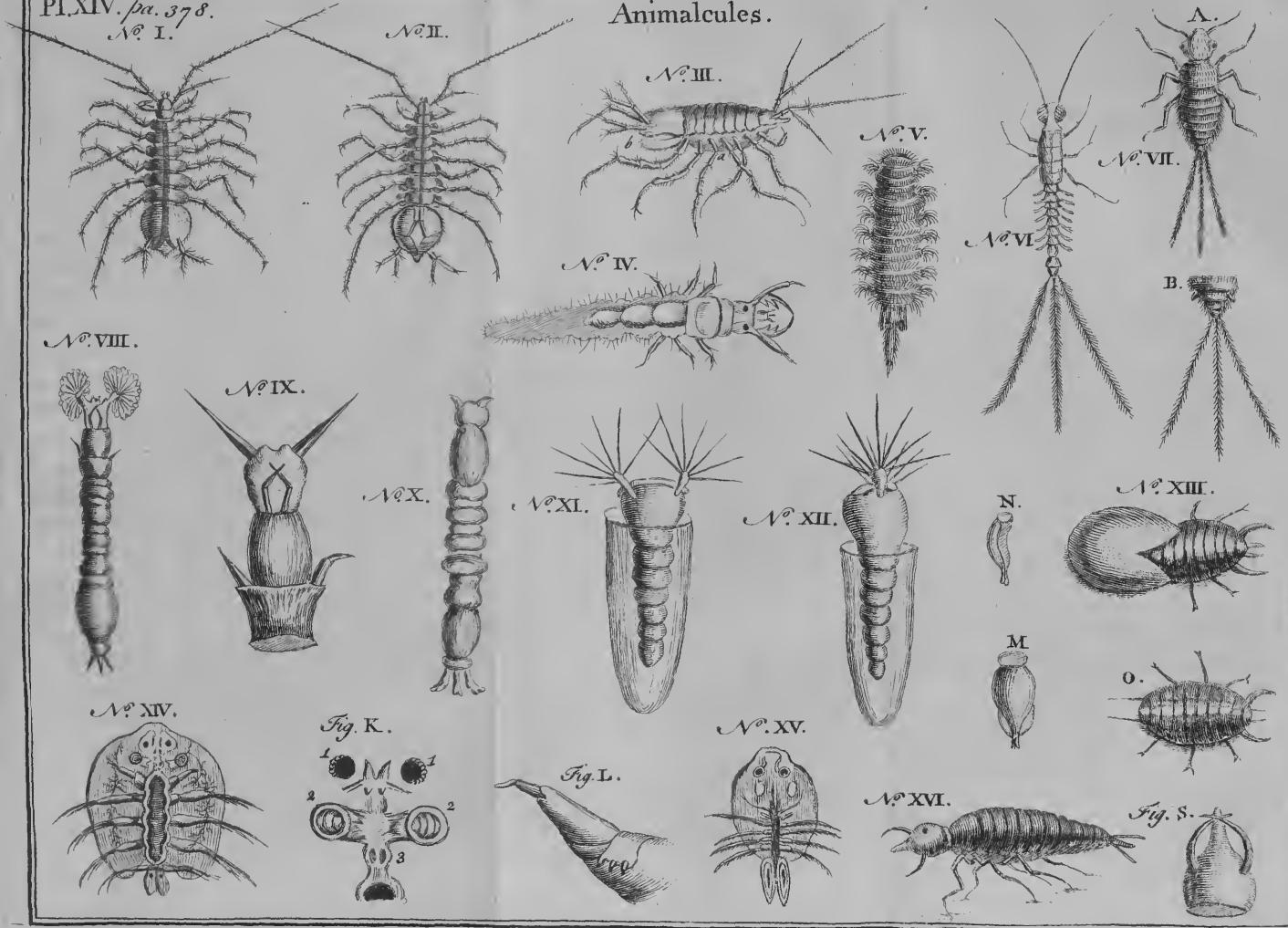
The Long-ſnouted SQUILLA, *&c.*

SEVERAL of the Inſects ſhewn N° XVI. were ſent to me from *Yarmouth*, in a Bottle of very clear Water. Some were about a Sixth Part as big as the Picture, and others a great deal leſs, but none of them alive: having either been ſuffocated by corking the Bottle too cloſe, or ſhaken to Death in bringing. They ſeem to be of the *Squilla* Kind, tho' a Species I have never ſeen before or ſince; but the Numbers that were ſent make me imagine they are frequent in thoſe Parts.

The Back is cruſtaceous, and joynted like a Lobſter's Tail; having ten Articulations, which divide it into eleven Parts, the middlemoſt of which are wideſt; for they leſſen from thence to the joyning on of the Head one Way, and grow tapering the other Way to the Extremity of the Tail, which ends almoſt in a Point, with a Sort of a Horn on each ſide, that extends beyond the Tail. The Scales of the Back reach down the Sides, and meet the upper Part of the Belly, beyond which they ſtretch out and overhang a little. The Belly is ſofter than the Back, and

Pl. XIV. *pa. 378.*

Animalcules.



J. Mynde sc.

and from its anterior Part proceed ſix Legs, on each ſide three, joynted in an odd Manner, and ſeemingly but aukward for walking with. But the moſt extraordinary Part of this Animal is the Head: a Draught whereof, magnified a great deal more, is given *fig.* S.— This Head is armed with a Pair of very ſharp hooked Forceps; between which it is lengthened out into a Sort of Proboſcis, whoſe Shape reſembles a Duck's Bill, and under that the Forceps can occaſionally be brought together, or even croſs each other, in order to ſecure its Prey. However, this Proboſcis did not divide nor open like a Bill or Mouth, neither could I diſcover that it had any Perforation: which makes it probable, that the Creature ſucks in its Nouriſhment intirely through the arched Limbs of the Forceps, in the ſame manner as the *Squilla* deſcribed *pag.* 358. And indeed our preſent Subject differs little from that voracious *Squilla* (which I take it to be another Species of) except in having a Proboſcis; whereas in that the Forepart of the Head between the Forceps is remarkably ſhort and flat ‡.

The Figures M and N, in this ſame Plate, are two Views of an Animalcule, many of which were diſcovered in Water that had been kept in a Glaſs Jar for ſome Months.— It

‡ Suppoſing the Proboſcis away, the Drawing N° XVI. will give a pretty good Idea of the *Squilla* pag. 358.

It is ſhewn at M in the Poſture of ſwimming, at which Time it moves pretty ſwiftly with its flat Head foremoſt: its Tail appears divided, and on each Side it extends a ſpreading Fin. At N it is ſhewn in Profil, and with its Fins drawn in, as uſually is the Caſe when it appears at reſt.

'Tis about the Size of the largeſt Animalcules found in the Infuſions of Hay in Water.

CHAP. XXVII.

A Letter from a Friend, *containing many curious* Microſcopical Obſervations, *&c.*

MANY of the Drawings in *Plate* XV. together with the Deſcriptions of them, were ſent me by a Gentleman, whoſe true Judgment in the Uſe of the Microſcope, and the Accuracy of whoſe Pencil in delineating therefrom, I have been long acquainted with: and whoſe Name, had I leave to mention it, would do great Honour to this Work, as his Friendſhip does to the Author of it. As it is therefore neceſſary to give his Deſcription of theſe curious Subjects in his own Words, I hope it may be excuſable to publiſh the whole Letter wherein they are inſerted, though written with the kind Partiality of a Friend.

SIR,

SIR,

I Am glad you are determined to publiſh your *Microſcopical Obſervations*. There are few who have been able like you, to gain Acceſs to the *Sacrarium in quo reducta et clauſa ſunt arcana Naturæ*; fewer ſtill who have Capacity to ſmooth the Path for others, and render the Examination of Nature by the Microſcope eaſy, ſhort and pleaſant: This you have done, and thereby have acquired a Title to the Obſervations which by your Book others have been enabled to make. What I ſend you are therefore of right your own. They have ſuffered indeed by not being under your Eye; their Defects are mine; what Worth they may have muſt be aſcribed to the Aſſiſtance of your printed Directions for the Uſe of the Microſcope.

You deſire to add to your proper Obſerſervations, ſuch as have been occaſionally made by your Friends: and as I am ſo happy as to be one of that Number, I ſhall here communicate what has occurred to me; perhaps of very little Conſequence, but as *rerum Natura ſacra ſua non ſimul tradit, nec omnibus illa patent*, the following Obſervations may have the Recommendation of Novelty in ſome Degree: and thoſe that are not intirely new I ſend to you, becauſe they tend to correct the imperfect or incompleat Obſervations already publiſhed.

The

The Drawings I made myſelf, when the Objects were under Examination, with Mr. *Cuff*'s Microſcopes, and as exactly as I could: and his Glaſſes are ſo excellent, that if there ſhould be found any Defects in the Figures, they muſt be attributed to my Inaccuracy and Diſuſe of Drawing. However, ſuch as they are, they are at your Service.

If theſe Things ſhall appear inſignificant, yet as in complying with your Deſire to have them, they afford me an Opportunity of ſhewing my Regard and Friendſhip for you, they are grateful and valuable to me.

I ſhall firſt give you an Account of what I have met with in Reſpect to Water-Inſects, which have, formerly, in many Inſtances, been thought imperfect in their Production, from the Imbecility of the Element to which their Creation was attributed: for aquatic Inſects may certainly be comprehended under *Animalia aquatica*, which *Seneca* calls, *tarda et informia, ut in aere cæco pinguique concepto.* But Attention to the Works of God makes manifeſt, that the Heavens do not only declare his Glory;—*Jupiter eſt quodcunque vides.* And indeed whoever ſearches the Waters will not find his Curioſity diſappointed; there he will ſee the Works of God diſplayed to thoſe who delight in them; and perhaps with greater Variety and more Profuſion than any other Element.

Fig.

Fig. 1. *Plate* XV. is an aquatic Insect of which we have two Drawings and Accounts, both very short; one in the *Phil. Transf.* 288, the other in the Letters of Mr. *Leeuwenhoek*, *Epist.* 121: and as this Insect has no Name, I will venture to call it the *Pediculus aquaticus*; for the Insect to which *Goedart* gives that Name, is now allowed to be the *Pulex arboreſcens*, or *arboreus* of *Swammerdam*. This Insect is a common one, and of the crustaceous Kind, but being pretty transparent it is a beautiful Object in the Microscope. When it is swimming it appears as *fig.* 1. It has five Pair of Legs; the first Pair on the Side of the Head are the longest it has, the four other Pair are short and upon its Belly: the first and second Pair are only visible as it swims. The Back is guarded with large Scales which proceed all the Way to the Tail, but from the eighth Scale they are frequently covered so thick with Hair, that only the Joynts or Divisions are discernable; but in other Postures, as in N° 3. the Scales are visible all the Way to the Tail. — The Tail is divided into two, with Hairs issuing from the Extremities of each Division, which in swimming are kept extended as in *fig.* 1. The Colour of this Insect is a pale brown.

Fig. 4. shews the Insect upon its Back, when all the Legs were visible; only the three

three loweſt Pair were laid back upon its Body, and kept in a conſtant Motion among the Hairs which cover its Belly, as if bruſhing itſelf. Nearer the Tail appear two Bags or Paps, hanging down, with a round Part at the Extremities, ſet with a few Hairs. I at firſt imagined theſe were the Receptacles of its Spawn, but have ſince found the Spawn placed much lower under the Tail: ſo that if this be the Place of the Spawn in the particular Inſect theſe Drawings were taken from, there may be different Species of theſe Inſects.

Fig. 3. is the ſame Inſect reclined on one ſide, when the Scales are moſt conſpicuous as they unite: eight of its ten Legs are viſible, and only one of the Paps appears hanging down.

It is ſaid in the *Tranſactions* that this Inſect is *monoculous*; and indeed it is not eaſy to diſcover its Eyes; they are placed in the Middle of the Head between the firſt Pair of Arms, and appear as in *fig.* 2. But it has two Eyes joined at the Bottom, both conical, and apparently ſeparated towards the Vertices as at *fig.* X. which ſhews theſe Eyes greatly magnified. When the Head of the Inſect is bent down, they may eaſily be miſtaken for one Eye, as is evident from their Appearance in *fig.* 3.

Mr. *Leeuwenhoek*'s Painter has given us a very bad Figure of this Inſect; his Account mentions

mentions the Manner of its carrying the Spawn. In *fig.* 2. towards the Tail, the Spawn Bags (at leaſt what I believed ſuch) were more extended than in any of the other Figures, but no Spawn was diſcovered in them; and ſince theſe Drawings I have examined more of the *Pediculi aquatici*, and find the Spawn fixed to the Tail much lower than thoſe Bags, and adhering to the Tail by two fine Ligaments, which are eaſily broke by the Inſect's ſtirring itſelf in the Water; and ſometimes all the Spawn comes away ſticking together, but oftener ſeparated and diſperſed among the Water. But though I have kept the Spawn ſome time, I never could find the young Inſects in the Water, which *Leeuwenhoek* ſpeaks of; but perhaps I have not had mine when the Spawn was come to an equal State of Maturity. I have ſent you this Account, becauſe the former Figures of this Inſect have been extremely imperfect in all reſpects, except the Spawn, which in Mr. *Leeuwenhoek*'s Drawing is exact enough ‡, and alſo as I found the Opinion received that this Inſect varied from all others in being *monoculous*.

‡ From finding this little Creature very frequently with its two Bags of Spawn adhering to its Tail, (as may be ſeen *Plate* IX. *fig.* II. of the *Microſcope made eaſy*; in the Drawing there, taken from Mr. *Leeuwenhoek*,) I have been accuſtomed to call it the *Bag-Animal*.

The two *Figures* 5 and 6 are I believe only different Appearances of the ſame Inſect, altho' there is ſome Variation in the Make of the Shells, but in all other reſpects they agree. I at firſt took this Inſect for the *Pulex arboreſcens*, and certainly it may be claſſed with it: but comparing it with *Swammerdam*'s Figure, it by no Means agrees therewith, nor with that which you ſhewed me †; for in this there are four *Brachia ramoſa*, in the other only two; theſe here are lower, and proceed from the Inſect under the Shell, the others are on each Side the Head and from the Shell. This Inſect has two *Antennæ*, and that has none, but a Bill like a Bird's. — I have drawn theſe as they appeared ſwimming with their Backs to the Eye, where the joyning of the Shells is viſible, which ſeemed ridged or marked with black Streaks as in the Figures: the Colour was a deep brown.

In ſome Pond Water with the *Lens paluſtris* I found the Inſects of which I ſent you the *Drawings fig.* 7. and 8. The firſt of theſe, *fig.* 7. was contained in four very thin tranſparent Shells. The two upper Shells united on the Back, and declined down the Sides till they met with two under Shells, making at the joyning of the Sides acute Angles,

† The Figure here mentioned may be ſeen *Plate* XII. *fig.* 14.

Angles, and at their joyning on the Back and Belly obtuſe Angles; but the upper Shells projected beyond the lower, which appeared beyond the upper towards the Tail, and probably by this means theſe upper Shells ſerved the Inſect inſtead of Fins, and to keep it up in the Water. All the Shells were elliptical.

The Figure repreſents the Inſect ſwimming, when the Head appeared beyond the Shells without any Antennæ or Feelers: the Tail was divided and extended: the Body was very apparent, and that Part which is on the Back in the Middle was in a conſtant Motion, alternately contracting and dilating. From each ſide below this Part there appeared a Ligament, terminating at the Circumference of the upper Shells, and may perhaps ſerve to keep the Shells ſteady, or to move them, if they be moveable, which I could not diſcover, for the Motion of the Inſect is very equable and ſmooth.

Fig. 8. is an Inſect which I am apt to believe is the ſame as *fig.* 5. in another Poſture, as it ſtands feeding in the Water: for it agrees in Colour and in the Shell exactly: the Antennæ and Arms have as near a Reſemblance as can be expected in ſuch differing Poſitions. It has indeed two Legs behind, wherewith it fixes itſelf to the Glaſs, which do not appear in the other; but if they are only to fix itſelf, they may be covered under

the Shell when ſwimming: however there is ſome difference in the Appearances. This Inſect ſwims well and nimbly, and by a rapid Motion of its Arms makes a ſtrong Current to bring it Food: (which Manner of feeding by a Current or an Eddy is common to many other Water Animals:) indeed, the Swiftneſs with which it moves not only the two Arms that are extended to draw Things to it, but alſo thoſe that are bent back, to drive along each ſide what is not fit for its Food, and the Way they co-operate all together to make a ſtrong Stream, is inconceiveably curious, as well as its Conſtancy and unwearied Application. When it is diſturbed it draws itſelf intirely into the Shell, and then appears not unlike a ſmall Freſh Water Muſcle.

The Inſect *fig.* 9. is very uncommon: I never met with any more of the Kind, nor with any Account of it. At firſt, when I found it among ſome Water in a leaden Ciſtern ſtocked with the *Nymphæ Vermiculi* of the Gnat, I fancied it might be the *Vermiculus* of that Inſect; eſpecially as the Head was not very unlike it, and it had pulmonary Tubes towards the Tail, as the *Nympha Vermiculus* has one. But as it never changed its State during three Weeks that I kept it alive, though the Gnats changed much ſooner, and it has many different Parts from thoſe,

thoſe, I muſt own I know not what Inſect it is, or what State it is in.

The natural Length of this Inſect was $\frac{1}{50}$th of an Inch, and its Breadth at the Shoulders or broadeſt Part $\frac{1}{130}$ of an Inch, according to the moſt exact Dimenſions I was able to take. Its Colour was a pale red or pink, which appeared deeper at the joyning of the Rings, but tranſparent. The Head was covered with a Shell, of a light brown, with two ſmall Eyes ſet round with Hair, as was alſo the Mouth, or at leaſt that Forepart of the Head on each Side of which it had the Antennæ bending inwards; but without Hair or any Joynts between the Shell of the Head and the firſt Ring of the Body; the Neck Part which appeared being a Continuation from the Head. Its Body conſiſted of eleven Rings, tapering ſomething all the Way to the Tail, but the two firſt and three laſt Rings not ſo wide as thoſe in the Middle. Under the firſt and ſecond Ring it had two Legs, (of which one only could be repreſented in the Figure) and their Extremities were ſet round with Hairs: between the tenth and eleventh Ring two ſmall Tubes aroſe, making an obtuſe Angle with the Forepart of the Inſect's Body, but an acute Angle with each other: the Ends of theſe Tubes were ſet round with Hairs and ſeemed to be open: I take theſe to be pulmonary: not that the Inſect always kept them upon

the Surface of the Water, though it often brought itſelf up till they were there, but becauſe in other Inſects ſuch like Inſtruments of breathing have been obſerved.

From the eleventh Ring the Tail begins; which is repreſented as it appears when the Inſect uſes it for ſwimming, and the whole of it is moſt viſible. It does not however keep it in this Poſture when ſwimming, but alternately extends it on each ſide and brings it together again as Men do their Arms in ſwimming. The Ends of each Branch of the Tail are ſet round with Hairs, and there ſeems to be a Joynt in each; but the Drawing will give you a better Idea of it than any Words. — I muſt not however omit ſaying ſomething of its Inteſtines. On each ſide there is a ſmall Veſſel running from the Head to the Tail, in which a conſtant Circulation of a pellucid Fluid was diſcernable: from the ſecond Ring to the fourth a dark-coloured Veſſel appeared, with the End next the Head ſeemingly open, or if covered, it was with a light-coloured circular Tegument. This Veſſel terminated in a fine Canal that ſeemed to enter another Bag of a clear white Colour, at whoſe End was a Gut or Canal that went quite down to the Tail. This Bag or Veſſel I conjectured might be its Stomach. Above this Gut, and at the ſeventh Ring, began another Veſſel or Ligament, I can't tell which; reaching (after croſſing itſelf twice)

to half the tenth Ring, and there ending abruptly, without communicating with any other Part; ſo that unleſs it be an Inſtrument for contracting the Body of the Inſect in walking along the Bottom of the Veſſel it is in, it ſeems only a Proviſion for ſome other State it is to aſſume.—I forgot to obſerve, that when the Inſect ſwims it uſes alſo its Fore-legs, bringing them up cloſe under its Head, and moving them back cloſe under its Belly.

If I could have found any more of this Kind, ſo as to have ventured killing it, by viewing it in the Solar Microſcope I might have given you a fuller Account of it, eſpecially of the Inteſtines: but as I was curious to diſcover what Changes it might undergo, I was very tender of it; however I was diſappointed, for it died after I had kept it three Weeks from the 5th of *September*, and in a Week after it was gone to pieces, ſo that I could not bring it to Town to ſhew it you as I intended.

Fig. 10. the only one of its Kind I have ever ſeen, is an Inſect called by *Monſieur de Reaumur* le Vers a queue de Rat, *the Worm with a Rat's Tail*, of which he has given an accurate Account, *Mem.* ii. *Vol.* 4. of his excellent *Memoires*. It is it ſeems the Vermiculus of a Fly with two Wings ‡; and if I

‡ It changes to a ſort of *Gad-Fly* or *Breeze*, about the Size and Colour of the *common Bee*, having only two Wings: the Tail Part broad and flat, and without any Sting.

had had his Book when this Inſect was found, I ſhould have made freer with it than I did, and not have preſerved it to obſerve its Change of State. The Drawing of it I ſend you, and for an Account of it refer you to *Monſieur de Reaumur*.

This Inſect was found in a Ciſtern of Rain-Water in *Auguſt*. The Length of its Body was $\frac{1}{8}$ of an Inch, but its Tail was four times the Length of the Body, though not extended near ſo far as it was capable of being. Above Half of the Tail was covered with a fine Down, in ſmall circular Diviſions, as the whole Body was: this Down or ſoft Subſtance is of a fine reticular Make, and at the Head there appeared two Antennæ within the outward Coat, which the Inſect by means of theſe Antennæ ſpread out or dilated at Pleaſure: ſo that the downy Covering ſeemed not ſo properly Part of the Inſect as to contain the Inſect. There were Fibres viſibly croſſing upon the Back, and running down to the Tail: And near the Tail, between theſe, a Veſſel of a black Colour appeared, growing gradually leſs to the Extremity. The Colour of the Inſect was a pale Aſh, the Tail and Antennæ black, the Extremity of the Tail ſet with Hair.

I take this Inſect to be the ſame with the Rat-tail'd Inſect of *Monſieur de Reaumur*, but by the Figure you will ſee it does not in all Reſpects agree with what he has deſcribed: perhaps

perhaps the Flies of which theſe are the Worms, or the Nymphæ, may vary in *England* from thoſe in *France*, where certainly, they are more common than here. The principal Difference is in the Legs, of which this had only ſix Pair, his ſeven: the Ends of them were ſet round with Hairs, and juſt under the Tail was a ſingular Fin, double, joyned at the loweſt Part in an acute Angle, and from thence growing ſmaller 'till it came to the Body. By means of this Fin, as a Rudder, it ſteered itſelf in the Water, on the Surface of which it kept the Extremity of its Tail: and when Water was added, it lengthened its Tail as much as it could: and if that did not reach the Surface, it raiſed itſelf higher, exactly as *Monſieur de Reaumur* obſerves, and about the ſame Length, (near five Inches,) before the Inſect was obliged to leave the Bottom of the Glaſs.

I ſhall now deſcribe an Inſect not found in Water, and very common in Time of Harveſt, but of which I have never ſeen any Drawing or Account. It is called the *Harveſt Bug:* is of a bright red Colour: ſo very ſmall as to be imperceptible to the naked Eye, and on the Point of a fine Needle reſembles a Drop of Blood. A Drawing taken from the Inſect preſerved in a Slider, and greatly magnified, is given *fig.* 11.

I had often heard of theſe Inſects, but did not give intire Credit to what I heard, 'till a Lady

Lady taking this out of her Neck convinced me of their Exiſtence and Taſte. They are extremely troubleſome to thoſe that walk in the Fields in Time of Harveſt, eſpecially to the Ladies, for they know what Skins are fineſt and eaſieſt to pierce. They have at the Head a Proboſcis near $\frac{2}{3}$ of their own Length; by which they firſt make way through the Skin, and then bury themſelves under it, (leaving no Mark but a ſmall red Spot) and by their ſucking the Blood create a violent Itching; a good Remedy for which is a little Hungary Water; though perhaps Spirit of Wine with Camphire might be more deſtructive to theſe little troubleſome Attendants of Summer Walks. They are I believe frequently carried in the Winds at their Seaſon, for I have ſince known them attack Ladies in a Garden, which was defended from a Corn Field by a Wall, too high for theſe Inſects to get over any other Way.

They have three Legs on each Side, with four Joynts ſet with Hair, as the Body is all round. The firſt Pair of Legs ariſe from the Back, juſt below the Eyes: the other two Pair from the Belly: it has alſo two ſhort Antennæ, one from each Side of the Head, which appears with a Diviſion in the Middle. I have ſometimes ſuſpected this little Creature might be a young Sheep-Tick, from its Figure and Way of burying itſelf: but then it ſhould be found rather where Sheep

Sheep feed than in Fields of Corn, growing, and before Sheep are ſuffered to come into thoſe Fields: and it is never got as I have heard in Graſs Fields, unleſs bordering upon Corn; but amongſt Wheat it never fails. If any one has a mind to make Trial upon this Inſect, how it comes to be amongſt Corn only, and yet lives by ſucking of Blood, he may eaſily find Abundance of them: for though they prefer the Ladies, yet they are ſo voracious, that they will certainly lay hold of any Man's Legs that comes in their Way.

I intended to have ſent you an Account and the Figure of the young Plant found in the Kidney Bean, but as that has been already accurately obſerved by Dr. *Grew* in the *Anatomy of Plants*, I need not trouble you with it: I ſhall therefore only take Notice of the Seeds of two other Plants which have not hitherto been obſerved, as far as I know.

In the Seed of the Lime Tree, which ariſes from a Stalk in the Middle of the Leaf, (as repreſented N° I. *fig. 1.*) there is a young Plant to be found, when the Seed is ripe, towards the Beginning of *October*.

The Seed of the Lime Tree is covered with a rough Skin, within which there is a Shell, but not hard; if this Shell be carefully opened there will appear a thin white Juice, incloſing ſix Pods or Bags, all tyed together, and adhering to that End of the Seed which is joyned to the Stalk, with very fine Fibres running

running up the Inside of the Shell, and appearing as *fig.* 2. These Pods when taken out of the Shell appear as *fig.* 3.

As the Seed advances in Maturity this white Juice grows harder, 'till it is quite ripe, and some one of these Pods has robbed the rest of Nourishment, by taking place within the Kernel, where it expands and excludes the rest, which will now be found sticking to the outward Cover of the Kernel dried to a brown Colour, with their Fibres embracing the Kernel, serving only as Cords to keep the Nourishment of their more fortunate Brother together, and appearing as *fig.* 5. So that if we follow the Opinion of *Swammerdam* and *Voltaire* in his *Metaphysics* of Sir *Isaac Newton*, pag. 54. of the English Translation, that *we see in Things a Disenvellopement only*, here the Author of Nature has provided in one Seed six Vermiculi, one of which alone is to become a *Nympha Plant:* for I never met with any Seed which contained more than one young Plant, in that State, which under *Voltaire*'s Authority, I may venture to call the *Nympha State.*

When the Seed is come to a sufficient Consistence, and ready to drop from the Tree, if it be opened it will appear as *fig.* 4: the inside filled with a white shining Substance inclosing a deep green Plant like a Flower, which arises by a small Fibre from that Part of the Seed to which the Stalk adhered, and per-

perpendicular to it. The Plant when taken out, and viewed in the Microscope, appears as at *fig.* 6. All the Fibres of the Leaves are discernable, altho' the Leaves are themselves thicker in proportion than those of the Tree, and seemingly turgid with Juice. These Leaves are double, and so tender and soft that I could only with the finest Needle separate them a little towards the Top, as I have endeavoured to represent in the Drawing.

N° II. is the Seed of *Asparagus.* —*Fig.* 1. is the red Berry as it grows from the Stalk, which contains, in a soft watry Pulp, six black shining Seeds, formed as I have tried to represent at *fig.* 2. Their Appearance, which ever way you view them, represents that Shape which *Bellini* calls *Pelecoides.* Each of these Seeds contains a hard white shining Substance with bright small Specks all over it; and, lying horizontally, a small Plant, white indeed but with a yellow Cast, plainly different from the Parenchyma in which it is situated. This Plant examined in the Microscope appears as *fig.* 4. with bright Spots like Papillæ all over it, and the bending Leaf at the Top tending to a faint green. When the Plant is taken out the Section of the Seed appears as *fig.* 3. in which the Bed of the young Plant runs quite through the Parenchyma, from one Side of the

the Covering or outward black Film to the other.

Altho' I shall endeavour to follow the learned Mr. *Hook*'s Advice to those who should correspond with the *Royal Society:* "to send the Kernel of Fact stript from the "Shell of Impertinencies," yet you will give me leave to observe two Singularities in this young Plant of the *Asparagus. First,* that its Position in the Seed is very different from most others: this lies horizontally, and not perpendicular to the Juncture of the Stalk, as others generally do; and indeed though I have seen many Seedling or Nympha Plants, I never met with one posited as the *Asparagus* is. *Secondly,* it has no Fibres or Liguments communicating with the Seed in which it is inclosed, but lies in it as a Nidus, adhering only by filling the hollow Bed exactly.

I have now given you an Account, and I fear a tedious one, of some things unobserved before, I believe, which have occurred to me: from your Friendship I am persuaded I need make no Excuse for it; if I was to make one, *Pliny* the elder *(et ille etiam Causas actitavit)* shall tell you my Sentiments as well as his own, *inter crimina ingrati animi et hoc duco, Naturam ignorare.*

I am, Sir,

Your sincere Friend and most

humble Servant.

CHAP. XXVIII.

Of luminous Water INSECTS.

IN my former Treatiſe on the Microſcope, I took Notice of the *ſhining Light* frequently found on the Shells of Oyſters, as beng produced by three Sorts of Animalcules, which are there deſcribed, according to the Account given of them by *Monſieur Auxaut* *. I had then no Opportunity of adding any Figure to that Account: but having not long ago been favoured (by a Friend whom I can depend on) with the Deſcription and Drawing of one Sort of Animalcule, which he had obſerved to occaſion ſuch Light, I ſhall inſert it here.

Having (he ſays) been ſometimes ſurpriſed at the Sparks of Light to be ſeen on the Shells of Oyſters, on removing them, or ſtriking on them, when newly taken from the Sea; he beſtowed ſome Pains to find out the Cauſe; and after many Examinations became perfectly convinced, that theſe ſhining Sparks are lucid Emanations from a minute Inſect, differing in its general Form but little from the common *Scolopendra*. This Inſect he carefully made a Drawing of from the Microſcope, an exact Copy of which is given

*. Microſcope made eaſy, third Edit. *pag.* 241.

given at Letter A.——Its Length was about the $\frac{1}{5}$th and its Breadth rather more than the 100th Part of an Inch.

The Body consists of twenty-eight Joynts or Divisions, exclusive of the Head and Tail Parts: each of these Divisions has a Pair of Feet belonging to it, (viz. one on each side) making the whole Number of its Feet 56, or twenty-eight Pair: they are all short and beset with Hairs.

The Tail Part is larger than any of the other Divisions, and has three pretty long Spines or Bristles proceeding therefrom. The Head is remarkable, on Account of its being armed with a Pair of Forceps uncommonly long and large in proportion to the other Parts: beginning much farther backwards than is usual in other Animals, and reaching beyond the anterior Part of the Head, in a Manner very convenient for seizing its Prey and carrying to the Mouth any thing it takes hold of. It is furnished with a Pair of Horns, and has besides at the Snout two short Antennæ or Feelers.

This little Insect can emit or conceal its Light: and sometimes its Lustre is so bright as to be discoverable even in open Day-light, especially on being touched or disturbed †.

Its

† The Rev. Mr. *Thomas Harmer* of *Wattlefield* in *Suffolk*, sent a Sea Insect to a Friend, who gave it me, preserved in Spirit of Wine. The Account Mr. *Harmer* wrote with it says,

Its Light is blueish like that of the Glow-worm, or a Spark of burning Brimstone.—My Friend observes, that our small Land *Scolopendra* has likewise the Property of shining in the Dark, which indeed has been taken notice of long ago *.

It

says, that opening Oysters he found this Animal between two Shells which stuck together. It was alive, but faint. Perceiving it emitted Light in the Shade, he carried it to a dark Place, where by irritating it on the Back with a Pin it shone pretty strongly more than once. The Light appeared on its Back towards the Tail, chiefly in two Spots; but, when more violently irritated, it was sometimes seen darting along the Back; and, particularly once, it was illuminated in streaks up to its very Head. The Insect growing more languid, he put it between the Shells where it was found, in some Water wherein Salt was dissolved, hoping it might revive; but in an Hour it was quite dead.—'Tis about $\frac{3}{4}$ of an Inch long, and $\frac{1}{5}$ of an Inch in Breadth; in Figure flat, with many Fins along its Sides from End to End.

* *Mouffet* writes, that his Friend Mr. *Brewer* found twice by Night in the Summer Season, amongst Heath and Moss, the *shining Scolopendra*, lucid and fiery; its whole Body emitted Light, but somewhat fainter than the Glow-worm. Mr. *Brewer* farther says,—"Happening to come home one Night in a Sweat, and in the Dark wiping my Head with a Linen Handkerchief, the whole Handkerchief appeared to me shining, and as it were on Fire; and whilst I viewed this seeming Miracle with Surprize, the Light was all collected in one Spot: whereupon folding the Handkerchief together, I called for a Candle, and on opening it discovered one of these *Scolopendræ*, which by being rubbed about my Head, had spread over the whole Handkerchief I know not what kind of flaming Vapour."—He affirms it was like the *Scolopendra* found in Gardens under Stones and Flower Pots. Vid. *Theatrum Insect.* Cap. xv. *De Cicindela.*

I take this to be the Kind of *Scolopendra* Mr. *Willoughby* describes, lying rolled up amongst Earth and Dung: Its Colour a brown or whitish yellow, the Head of a pale Chesnut, having two Antennæ; its Length half an Inch, its Tail forked:

It seems not improper to say somewhat in this Place concerning the shining of Sea Water, since not without the Appearance of Reason, it has been supposed owing to vast Numbers of luminous Insects, of which possibly in the Waters there may be various Kinds as well as upon the Land.

A curious Enquirer into Nature †, dwelling at *Wells*, upon the Coast of *Norfolk*, affirms, from his own Observations, that the Sparkling of Sea Water is occasioned by Insects. His Answer to a Letter wrote to him on that Subject runs thus: "In the Glass of "Sea Water I send with this are some of the "Animalcules which cause the Sparkling "Light in Sea Water; they may be seen by "holding the Phial up against the Light, "resembling very small Bladders or Air "Bubbles, and are in all Places of it from "Top to Bottom, but mostly towards the "Top, where they assemble when the Wa-"ter has stood still some Time, unless they "have been killed by keeping them too "long in the Phial.

"Placing one of these Animalcules before "a good Microscope; an exceeding minute "Worm

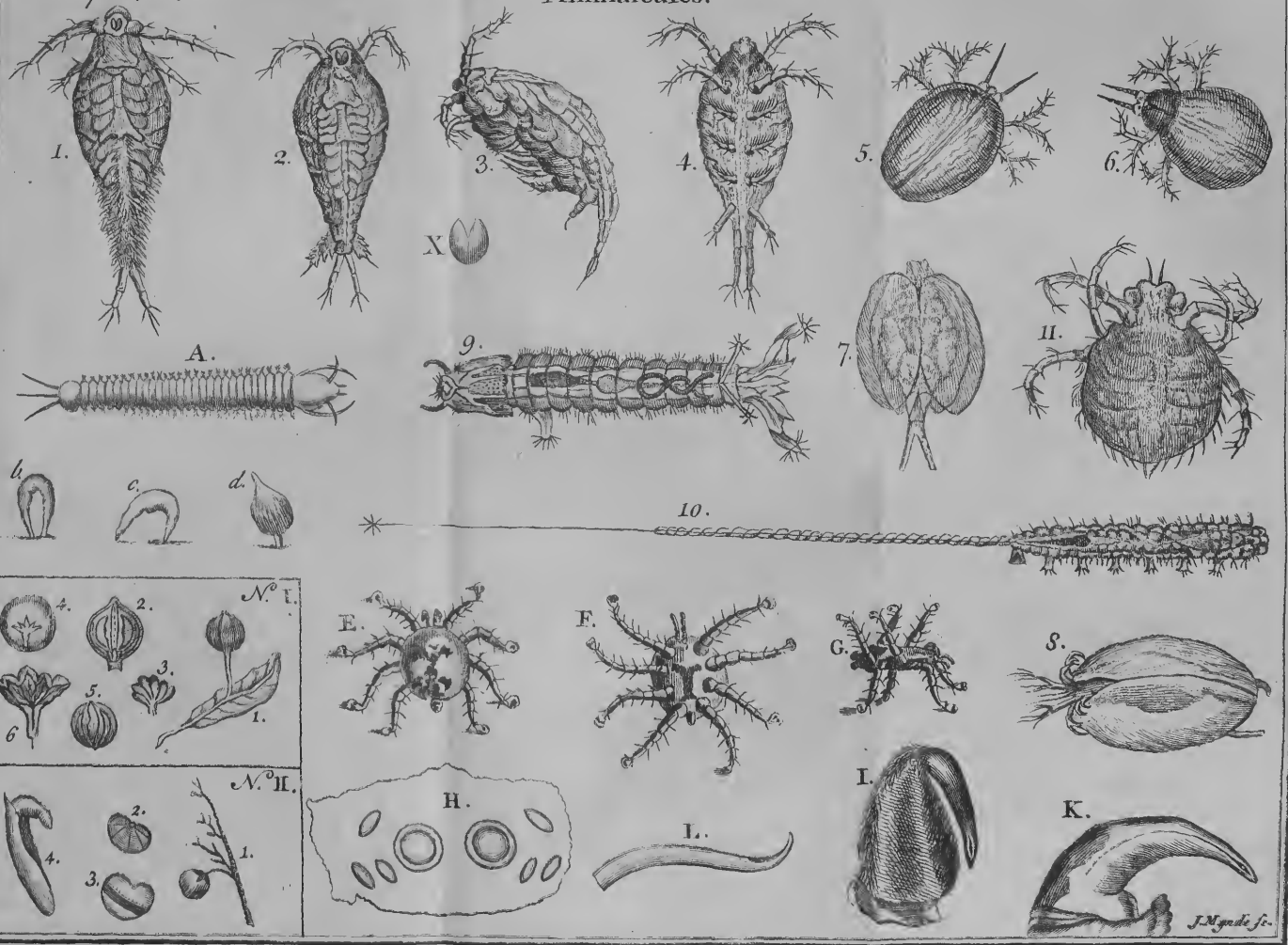
its Feet 96, (without including the Forceps at the Tail) that is 48 Pair.

One Evening after Rain, says Mr. *Ray*, I found a small *Scolopendra* of this Sort shining like a *Glow-worm*; 'twas covered with a slimy Matter, which being wiped away, it ceased not to shine. Vid. *Ray Hist. Insectorum*, pag. 45.

† Mr. *Joseph Sparshall.*

Pl. XV *pa. 402.*

Animalcules.



" Worm may be discovered, hanging with " its Tail fixed to an opake Spot in a kind " of Bladder ‡, which it has certainly a " Power of contracting or distending, and " thereby of being suspended at the Surface, " or at any Depth it pleases in the including " Water."

The abovementioned Phial of Sea Water came safe, and some of the Animalcules were discovered in it, but they did not emit any Light, as my Friend says they do upon the least Motion of the Phial when the Water is newly taken up. He likewise adds, that at certain Times, if a Stone be thrown into the Sea, near the Shore, the Water will become luminous as far as the Motion reacheth: this chiefly happens when the Sea hath been greatly agitated, or after a Storm.

Jos. Vianelli, M. D. of *Chioggia* in *Italy*, in his Enquiry into the shining of Sea Water in the Night Time, (which, he says, is seen with Wonder in the Lakes of *Chioggia*, from the beginning of Summer until Autumn, especially where Sea Weeds abound,) relates, that he brought from thence, one Summer's Night, a large Vessel of this Sea Water, which being stirred about by his Hands in a dark Closet, sparkled very much; but after it was filtered through a close Piece of Linnen it afforded no Light at all, notwithstanding

‡ A Drawing of this came with the Account, but it was too late for the Engraver.

ing all the Motion that could be given it, whilſt the Linen appeared covered with numberleſs lucid Particles, thereby proving the Light to be ſomething diſtinct intirely from the Water.

Then examining ſome of the Sea Weeds, he perceived thirty at leaſt of the like ſhining Particles upon every little Leaf, and ſhaking them over a Sheet of Paper one of the ſhining Bodies was thrown upon it, which being wrapped up in the Paper emitted Light quite through it. Unfolding the Paper, and viewing this luminous Body attentively, he found it far leſs than a ſmall Hair, extremely delicate and tender, and of a deep yellow Colour: and by the Help of a Microſcope he diſcovered it to be a living Animalcule, of a curious and ſingular Structure, and could not enough admire the Splendour of its Light. It was ſomewhat like a Caterpillar, and conſiſted of eleven Segments or Ringlets, along which near the Belly were a kind of Fins or Inſtruments of its ſeveral Motions. From its Head iſſued two Horns, and the Tail appeared twiſted.

He obſerves, that theſe glittering Sea Water Inſects are intirely luminous, whereas the Glow-worm emits Light only from a Part about the Tail; and, moreover, that when at reſt they do not ſhine at all, though they ſend forth a prodigious Brightneſs as ſoon as their little Bodies become agitated.

Hence

Hence he accounts for the Fiſhermens foretelling a Tempeſt from an extraordinary glittering of the Sea and Lakes: theſe Animalcules as he ſuppoſes being diſturbed and put in Motion at the Approach of ſuch a Change.

Theſe Animalcules are found, he ſays, at the beginning of Summer, more plentifully amongſt the Weeds than in any other Part of the Water: but they increaſe ſurprizingly in a ſhort Time, and diſperſe themſelves in the Waters every where †.

In *Plate* xv. *b*, *c*, *d*, repreſent a very ſmall Inſect found in ſome Ditch Water. *b* and *c* ſhew it in the Action of moving from Place to Place, which is performed by faſtening the Tail-End upon the Plate of Glaſs, bending the Body, extending and directing the Head downwards, then fixing the Head and drawing the Tail to it, whereby is made what may be termed one Step: and by repeating theſe Steps its Progreſſion was pretty nimble, and much reſembled that of the Species of Caterpillars called *Loopers*. Its Poſture when at reſt after being tired with Motion, or juſt before it began to ſet forwards, is ſeen at *d*.

I could not by the ſtricteſt Obſervation diſcover any ſuitable Apparatus about the

† A large Account of this may be ſeen tranſlated from the *Italian*, in the *Univerſal Magazine*, for *December*, 1751.

Head, or elſe from its Appearance ſhould have judged this little Creature to be a Species of the *Wheel-Animal*, which it imitates in other Reſpects very nearly.

CHAP. XXIX.

The LOUSE *of the* BAT.

MOST living Creatures are ſuppoſed to have their Lice, Fleas, or little Tormentors, of Kinds and Forms peculiar to themſelves: ſuch have been found in great Numbers on many Sorts of Beaſts, Birds and Fiſhes, at ſome particular Seaſons; Flies, Bees, Earwigs, Spiders, and many other Inſects are ſometimes in like manner peſtered with them: nay, even the nimble Flea which teazes us and ſucks our Blood, is not free itſelf from Blood-ſuckers, which harbour very conveniently under the Scales of its Neck, and about its Legs and Belly, clinging too faſt to be ſhaken off. We are obliged to Seignior *Redi* for the Figures of the *Pediculi* peculiar to ſeveral Kinds of Beaſts and Birds; but I ſuppoſe he had no Opportunity of obſerving that of the Bat, which I am now going to deſcribe.

The little Animal which the Reader is directed to take notice of, at the Letters E, F, G, *Plate* XV. was found adhering firmly to

to the filmy Wing of a Bat then but newly dead, and is undoubtedly the Vermin of that Creature: many others were probably concealed under its ſhort thick Hair, but being intent on examining this with the Microſcope and making Drawings of it, I omitted ſearching after more.

Its Body is nearly circular, and about the 30th Part of an Inch in Diameter. It is furniſhed with eight Legs, each having ſix Joints: the laſt Joint terminates in a tranſparent Tuft or Ball, like thoſe at the Feet of ſome Flies, but much larger and more ſpreading in proportion to its Size, whereby it is enabled to faſten itſelf ſtrongly to whatever it ſtands upon. Two ſmall Antennæ or Feelers are placed at the Anterior and a ſmall Proceſs or Tail at the Poſterior Part of this Animal. A periſtaltic Motion, or rather a Contraction and Dilatation, are alternately carried on through the Inteſtines, which appear more opake than the Parts about them, and ſomewhat in the Shape of the Letter X.

This Animal is ſhewn in its natural walking Poſture with its Back uppermoſt at E, and again at F with its Back downwards and its Belly next the Eye. It lived more than twenty-four Hours between two Talcs, and died nearly in the Poſture ſhewn at E, F, as it ſtill continues in the Slider now before me.

As the Bat is extremely ſwift in its Flights and Returns, it was requiſite the Vermin living on it ſhould have ſome extraordinary Power of preventing its being thrown off; and accordingly this little Inſect is not only provided with larger Tufts or Balls than uſual at the Extremities of its Feet, but has alſo another very remarkable and uncommon Means of preſerving its Situation: for on any ſudden Emergency, inſtead of walking on its eight Legs, as it uſually does, it can, in an Inſtant, turn four, ſix, or all of them occaſionally, ſo far backwards as to catch hold of any thing, and walk on them with its Back as eaſily as with its Belly downwards; and I often obſerved it with four Legs in their right Poſition, and the other four erected over its Back and ready to lay hold as at G. Hereby it is enabled to ſhift its Poſture inſtantly, yet ſtill maintain its Ground notwithſtanding the ſwifteſt Motions, as I had the Pleaſure of experiencing in ſeveral Attempts to jerk it off from a Quill, from my Finger, and from other Things it fixed itſelf upon, which all my Endeavours could not effect.

CHAP.

CHAP. XXX.

Obſervations on a large SPIDER.

HAVING received a Spider from the Iſland of *Nevis* of a larger Size than I had ever ſeen, I pleaſed myſelf with the Hope of obtaining thereby a better Knowledge of Spiders in general, than I poſſibly could by the niceſt Examination of the ſmaller Kinds.

On meaſuring it pretty exactly, the Length of its Body and Tail was found to be $2\frac{1}{8}$ Inches: the Breadth of the Body and the wideſt Part of the Tail very near an Inch. It had ten Legs, of which the foremoſt two were ſhorter than the reſt, but the other eight were each three Inches long at leaſt, and in their thickeſt Parts a Quarter of an Inch Diameter. Such were the Dimenſions when dryed, and conſequently much ſhrunk and leſſened: when alive it probably appeared nearly twice as big. The whole Body and Limbs were thickly covered with long Hair. The Body was of a brown Colour; the Tail was alſo brown, except one longitudinal indented Stripe of white, which paſſed along its Middle from where it joyns the Body to the Arms. The Termination of each Leg was a curious Tuft of long ſoft Hairs, under which lay concealed a Couple of exceeding ſharp

ſharp hooked Claws, which muſt be greatly ſerviceable in clambering, to cling to any thing, or to ſeize the Prey.

The Body was cruſtaceous, having a Shell as hard as that of a ſmall Crab, the Tail Part was ſoft and downy; on the Back both of the Body and Tail the Hairs were ſhorter than elſewhere. The two Fangs were ſtrong, black, hard and horny, terminating and being Parts of two ſhort thick Limbs to which they were articulated, projecting from the Body directly before the Mouth. One of theſe Fangs magnified about three times is ſhewn at Letter I. They were not placed horizontally like a Pair of Forceps, fitted to catch and hold Things by bringing their Points to meet, as in moſt of our Engliſh Spiders, but they lay Side by Side with their Points bending downwards, and in Readineſs to ſtrike either ſingly or together, after the Manner of the *Tarantula*. Theſe deadly Weapons of the Spider I was very induſtrious to examine, and by my Glaſſes could diſcern very diſtinctly a minute Opening or Slit near the Extremity of each Fang juſt in the Front thereof, through which one can hardly doubt a poiſonous Juice was ready (when the Creature was alive) to be ejected into the Wounds it made. This Aperture is deſcribed by Mr. *Leeuwenhoek*, in the 272d

Number

Number of the *Phil. Tranſ. pag.* 868 ‡: but Dr. *Mead* having examined the Weapons of ſeveral Spiders, and particularly of one very large, without finding it, was inclinable to believe, when he publiſhed his curious Account of Poyſons, that Mr. *Leeuwenhoek* had been miſtaken, and that the Fangs were capable of inflicting a Wound only; into which a poiſonous Liquor was inſtilled afterwards by a ſhort white Proboſcis thruſt out of the Spider's Mouth †. Having alſo never ſeen it myſelf at the Time I wrote my *Treatiſe on the Microſcope*, I was then of the ſame Opinion. But as ſoon as I made the above Diſcovery, which was in *April* 1746, I ſhewed the Fangs I have been deſcribing to Dr. *Mead*, who was much pleaſed with a Sight of this Aperture, and with his uſual Candor gave it as his Opinion, that as amongſt Serpents ſome Kinds only are poiſonous, and have Teeth that are perforated for the Emiſſion of their Poyſon, *viz.* the *Rattle Snake*, the *Viper*, &c. whereas the Generality are harmleſs and have no hollow Teeth; ſo likewiſe ſome Kinds only of Spiders are poiſonous, or have any Perforation in their Fangs: but ſuch whoſe Fangs are perforated may be ſuppoſed uncommonly dangerous.

It

‡ See alſo Arc. Natur. Tom. IV. Pars II. *pag.* 39.

† *Vid. Mechanical Account of Poyſons*, third Edit. *pag.* 88.

It would not be ſtrictly honeſt to paſs over this Subject, without declaring in Juſtice to the Memory of Mr. *Leeuwenhoek*, that notwithſtanding I have ſometimes thought him miſtaken in his Deſcriptions of Things examined by the Microſcope, it has ſeldom happened, but that afterwards I have found ſuch his Deſcriptions true, and that the Objects I had formerly judged from were not exactly of the ſame Sort, or in the ſame Perfection as his: And this I hope will make others cautious, not immediately to determine in Matters of this Nature from a ſingle and perhaps a ſlight Examination; which I believe too often has been the Caſe.

Having ſatisfied myſelf concerning the Fangs of this Spider, I proceeded to an Examination of its Eyes, which I found to be eight, ſituated on the Summit of the anterior Part of the Body: for I think a Spider cannot properly be ſaid to have any Head. I cut out a Portion of the Shell or Cruſt in which the Eyes were placed, that I might bring them with more Convenience to my Glaſſes. And I ſoon ſaw that the two Middle Eyes were much larger and more remarkable than the reſt, and ſeemed exactly round, and that the three ſmall ones on either Side were oval. The Diſpoſition, proportionable Size and Appearance of them all together may be ſeen at H.

After

After clearing away from the inner Part of the Shell the Blood Veſſels and other Integuments of the Retina, or perhaps the Brain, the two larger Eyes (which were each as big as a middling Pin's Head) appeared to be tranſparent ſpherical Bodies of an Amber Colour. Part of each Sphere projected externally beyond its Socket, but the largeſt Part was ſunk internally within it, and there was round each a circular tranſparent Membrane by which it ſeemed to be faſtened*.

The Figure and Tranſparency of theſe Eyes raiſed in me a Deſire to ſee with the Eye of a Spider; and therefore cutting them out very carefully, (for in their natural Situation they could not anſwer my Purpoſe) I took the Pains to ſet each of them in a Pin-

* *Spiders* Eyes are not pearled or compoſed of ſmaller Eyes like thoſe of *Flies*, *Beetles*, and moſt Kinds of Inſects: they reſemble more the Eyes of Quadrupeds, but are not moveable, which is probably the Reaſon why Providence has furniſhed the Spider with more Eyes than Inſects that have Eyes pearled, or Animals whoſe Eyes can turn: for as Safety requires that Creatures ſhould be able to diſcover Danger, or even their Food, on whatever Side it lies, ſome have pearled Eyes, or more properly Cluſters of Eyes, which (tho' not moveable) are directed every Way: the Eyes of others are as it were multiplyed by Motion; but Eyes like thoſe of the *Spider*, and immoveable, would be unable to anſwer theſe Purpoſes, unleſs there were more than two.

Indeed the *Shepherd Spider* has two Eyes and no more: but then its Legs are ſo very long, its Body ſo ſmall, and thoſe Eyes are placed in the Middle of its Back on ſuch an Eminence, and in ſuch a Direction, that they take in nearly a whole Circle. A fuller Account of this Spider and Figure of its Eyes may be ſeen in Dr. Hook's *Micrographia*.

Pin-Hole made through a Piece of Card, whereby I could employ them to view Objects with. Their magnifying Power was very great, and had they been taken from a Spider newly dead, I have Reaſon to believe they would have given me much Pleaſure: but having been drying for ſome Years, they had contracted a Cloudineſs that prevented Objects being ſeen through them with any tolerable Diſtinctneſs. I am not however without Hopes of bringing this Experiment ſome Time or other to ſucceed, even with our *Engliſh* Spiders.

The wounding Inſtruments of moſt Animals, whoſe Bite or Sting is poiſonous, reſemble in their Contrivance the Fangs of the Spider juſt now deſcribed; as will be eaſily comprehended by viewing the Tooth of a Viper, pictured in this ſame Plate at L; wherein a ſimilar Opening is ſhewn, through which, on biting, a poiſonous Juice is thrown into the Wound; and alſo by the Fang of an *Indian Scolopendra* or *Millepes*, near whoſe Point there appears a like Opening, ſerving to the ſame Purpoſe, at the End of a long Slit or Fiſſure, as may be ſeen at K. The Weapon with which the *Scorpion* ſtrikes has likewiſe ſuch an Aperture.

CHAP. XXXI.

Miſcellaneous Obſervations.

HAVING deſcribed all the Figures given in the preceding Plates, I ſhall add a few Obſervations in a miſcellaneous Manner.

In the Waters of ſome Ditches there is found a very ſmall Sort of Leech, of a pale brown Colour, whoſe Length is about half an Inch when extended fully. Several Months in the Year its young ones are carried about with it where-ever it goes, ſticking faſt underneath its Belly. Their Number is uſually 8, 10, or 12; and if ſeparated from the Parent, even to ſome Diſtance, they immediately replace themſelves, and that ſo regularly they might eaſily be miſtaken for Legs, whilſt they are ſtretching themſelves out beyond its Body, with their Heads waving to and fro, which is their conſtant Poſture when the Parent Animal is in Motion. This Subject deſerves farther Examination.

Curious Caſes are made by a ſmall Worm or Maggot, with admirable Dexterity, of the Stalks of *Duckweed*, which the little Creature bites aſunder with its Pincers, places with great Order and Exactneſs like the Threads of a Linen Cloth, and glews together. 'Tis diverting to ſee the briſk Inhabitant come a little Way out of its Door, either for Food or Pleaſure, and immediately

ately on the Apprehenſion of Danger pop in again, leaving nothing to be ſeen but a few green Stalks.

In the Spring of the Year I have ſeveral times obſerved great Numbers of little Caſes, on a Row of Pales by the Side of the New River at *Enfield*, made in the prettieſt manner imaginable of the green microſcopic Moſs growing on the ſame Pales. They were open at both Ends, and about a quarter of an Inch in Length: each contained a little black Maggot, that put out its Head or Tail occaſionally, and became at laſt a ſmall black Fly.

Amongſt the *Eels in Vinegar* one ſhall ſometimes find accidentally a pretty and ſurprizing Phænomenon, *i. e.* a Chain or Series of minute Globules ſeemingly ſtrung together like a Necklace of Beads. Theſe are nothing more than a Row of Air Bubbles lying one behind another in the dead Body of one of the *Anguillæ*; which Body from its great Tranſparency is not viſible, unleſs by the greateſt Magnifier.

My good Friend Dr. *Miles* happening to take Notice of a bright green *Mouldineſs* on the Bark of ſome Fire-wood: and, by a Lens of an Inch Focus, finding it to be Numbers of minute *Fungi* of a regular Appearance, he employed a large Magnifier, through which their ſpherical Heads ſeemed as if they were nothing elſe but Globules of Seeds. He obſerved

obſerved, at the ſame time, ſeveral Seeds adhering to the tranſparent Foot-ſtalks which ſupported the Heads, and many ſcattered on the *Glaſs Plate* whereon the Subſtance was placed for view; whereby he had an Opportunity of ſeeing many diſtinct Seeds, nearly of an oval Form, but ſeveral times larger than the Seeds of *common Muſhrooms*, even when ſeen with the ſecond Magnifier, and the latter with the firſt.—He ſays, he has often viewed the Heads of a ſmall Kind of coriaceous Fungus of about $\frac{1}{3}$ Inch Diameter, and always found the Seeds on their Gills much larger than thoſe of any other Muſhroom he had examined, tho' rather leſs than thoſe this unregarded Plant produces.

He ſent with this Account a Piece of Wood with the *Mouldineſs* thereon, and alſo ſome of it on a Slip of Glaſs: both which I examined carefully to determine the Bigneſs of the Heads and their Seeds: and viewing the Spherical Heads of the middle Size, (ſome being larger and others ſmaller) I found, (according to my *Micrometer*) that 3 of them took up the Side of a Square, 70 of which Squares made an Inch in Length: conſequently thrice 70, or 210 of theſe *Fungi*, make a Line of one Inch: or, in other Words, the Diameter of theſe *fungous Bodies* is, at a Medium, the 210th Part of an Inch.

The Seeds are oval; and I find, by the ſame *Micrometer*, that 10 of them laid by one another the ſhorteſt Way of their Diameter, or 8 of them the longeſt Way, fill up the Side of a Square, 270 of which Squares make an Inch in length. —Taking therefore 9 as the Medium, 270 times 9, or 2430 of theſe Seeds will be required to make a Line of an Inch in length; or in other Words, each Seed is the 2430th Part of an Inch in Diameter.— And according to theſe Calculations 44100 of the Spherical Heads, or 5,904,900 of their Seeds, may lye by one another in the Surface of an Inch ſquare.

Yet minute as the Seeds of this little *Fungus* are, the Doctor obſerves very juſtly, that they are bigger than thoſe of ſome others of the ſame Genus which exceed it Thouſands of Times in Bulk. For the Seeds of a very large *edible Muſhroom* being examined, by a Glaſs magnifying 320 times in Diameter, and their Figure being elliptical, 7 of their longeſt and 8 of their ſhorteſt Diameters were found equal to the Length of a Line known to be the 500th Part of an Inch. So that the longeſt Diameter of each Seed was the 3500th, and the ſhorteſt the 4000th Part of one Inch in length, and 14,000,000 of ſuch Seeds would be required to cover a Surface of one Inch ſquare *. The

* All the Species of *Fungi* were formerly ſuppoſed to bear no Seeds: *Ray* ſays of them, *nullo nec Semine nec Flore*; but good Glaſſes now convince us of their producing Seeds in vaſt abundance, growing commonly between the Gills.

The *proportionable Size* of Fruits and Seeds to the Trees and Plants that bear them, comes under no Rules that correſpond with our Conceptions. The *Beech* and *Aſh* are produced from Seeds ſmaller than the Garden *Bean*. The *Oak* has for its Fruit only a ſmall Acorn; whereas the *Pumpkin*, whoſe Weight ſometimes exceeds 100lb. is the Production of a feeble creeping Plant, unable to ſupport itſelf, much leſs its enormous Fruit. The *Vanilla*, (climbing to the Height of ſeveral Feet) produces in long Pods Seeds ſo ſmall, their Diameter is not more than the 100th Part of an Inch. Then ſuppoſing the Cavity of its Pod equal to a cylindrical Tube of $\frac{1}{10}$ Inch Diameter, and its Length to be ſix Inches, (which Dimenſions are taken with great Moderation) the Number of Seeds in one ſingle Pod will be more than 47000.——Theſe Seeds ground with Chocolate give it a rich Perfume.

I could add many more Obſervations, which perhaps ſome of my Readers might be pleaſed with; but finding this Work has grown under my Hands, much beyond the Size I intended, I ſhall haſten to conclude this Part with recommending the *Study of Nature* to all who have Leiſure and Opportunity for it, as affording the moſt reaſonable Pleaſure the Mind of Man is capable of enjoying.

The World around us is the mighty Volume, wherein the Great Creator with his

own Finger has deſcribed himſelf. Human Writings conſiſt of *Lines* and *Figures* intended to denote the *Sounds* or *Words* of Language; which being at firſt arbitrarily apply'd, were afterwards by common Conſent and Cuſtom allowed to repreſent certain *Ideas*, tho' without any Reſemblance to them. And as very different *Sounds* and *Marks* have been employed, by Nations Strangers to each other, to expreſs and denote the ſame *Objects of the Senſes*, or *Conceptions of the Mind*, hence aroſe different *Languages* and *Characters*, which muſt therefore be unintelligible to all who have not previouſly been inſtructed in their Signification and Uſe; nor can be attained without a great deal of *Pains* and *Attention*. But the *Book of Nature* is written in an *univerſal* and *real Character*, which every Man may read in his own Language; for it conſiſts not of *Words* but *Things*, which picture out the Perfections of the DEITY. The ſtarry Firmament every where expanded, with its numberleſs Syſtems of Suns, and their ſurrounding Planets, the Regularity, Harmony, Order and Conſtancy of their Motions, declare the Immenſity and Magnificence, the Power and Wiſdom of their Creator. Thunder, Lightening, Tempeſts, Hurricanes, Earthquakes, and Volcano's, ſhew the Terror and Deſtruction of his Wrath. Seaſonable Rains, Sunſhine, and plenteous Harveſts, denote his Bounty and Goodneſs, and his Regard for the Hap-

Happineſs of all his Creatures; and demonſtrate how, when his Hand is open, he fills all things living with Plenteouſneſs. The conſtant Succeſſion of Generations in Plants and Animals, implies the Eternity of their firſt Cauſe. Life every where ſubſiſting in Millions of different Forms, ſhews the boundleſs Diffuſion of his Animating Power; and Death the infinite Diſproportion between him and every living Thing.—Even the Actions of Animals are an *eloquent* and *pathetic Language*; thoſe that want the Help of Man, have a thouſand engaging Ways, which like the Voice of God ſpeaking to his Heart, command him to preſerve and cheriſh them; whilſt the Looks and Motions of ſuch as would do him harm, ſtrike him with Terror, and warn him to fly from or arm himſelf againſt them. In ſhort, every part of Nature directs us to Nature's GOD; for according to *Lucan* in that fine Speech he makes for *Cato*,

JUPITER *eſt, quodcunque vides, quocunque moveris*;

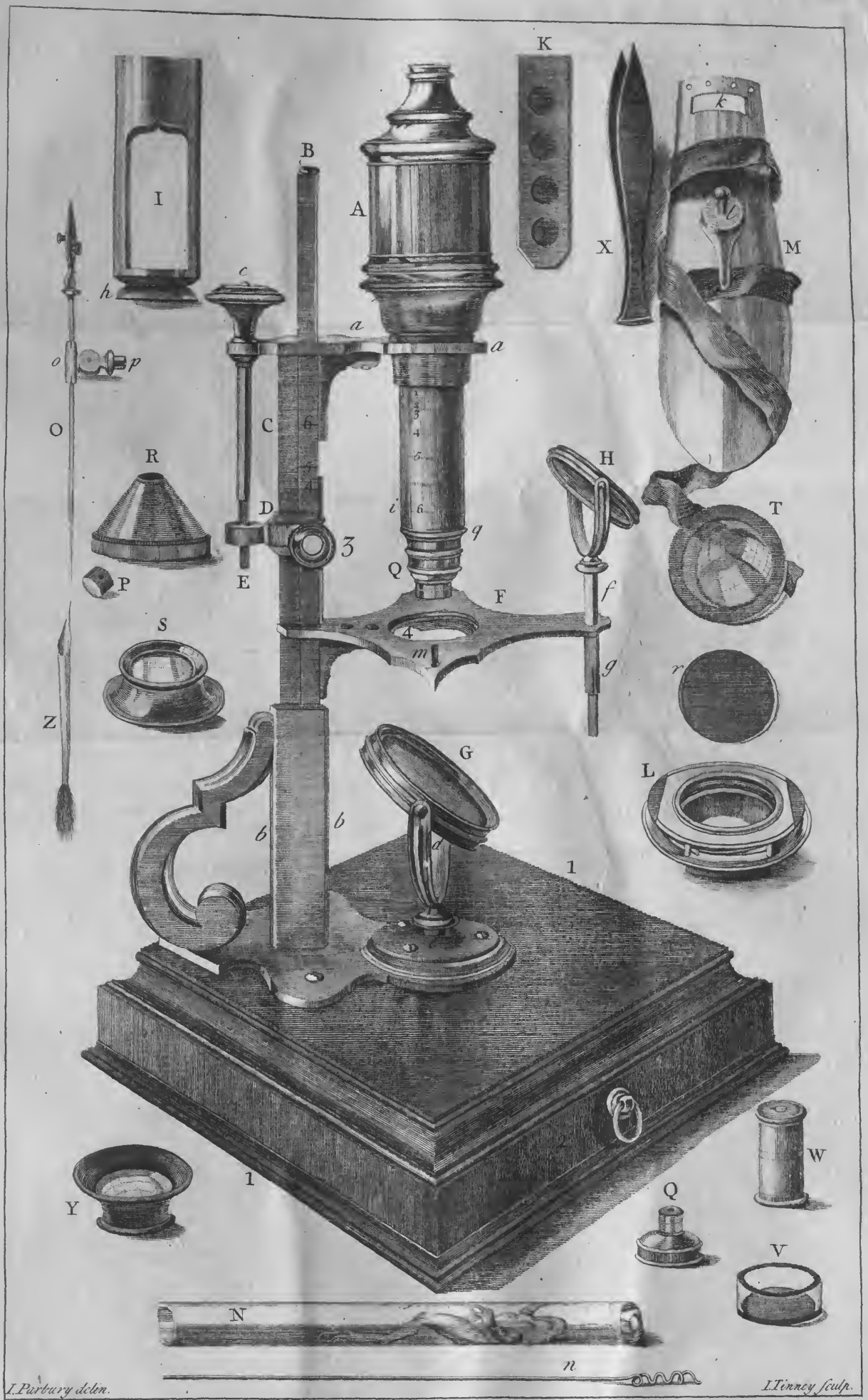
which I ſhall tranſlate with great Liberty, and by the Way of Paraphraſe,

Range where you pleaſe, through Water,
Earth and Air,
GOD is in every Thing, and every where.

Some Account of a new conſtructed Microſcope, *uſed in the foregoing* Experiments.

THE cumberſome and inconvenient DOUBLE MICROSCOPES of Dr. *Hook* and Mr. *Marſhal*, were many Years ago reduced to a manageable Size, improved in their Structure, ſupplied with an eaſy Way of enlightening Objects by a Speculum underneath *, and in many other Reſpects rendered agreeable to the *Curious*, by Mr. *Culpepper* and Mr. *Scarlet*. Some farther Alterations were however wanted to make this Inſtrument of more general Uſe, as I fully experienced in the Year 1743, when examining daily the Configurations of Saline Subſtances, the Legs were continual Impediments to my turning about the Slips of Glaſs; and indeed I had found them frequently ſo on other Occaſions. Pulling the Body of the Inſtrument up and down was likewiſe ſubject to Jerks, which cauſed a Difficulty in fixing it exactly at the Focus: there was alſo no good Contrivance for viewing opake Objects. Complaining of theſe Inconveniencies, Mr. *Cuff*, the Optician, applyed his Thoughts to faſhion a Microſcope in another Manner, leaving the Stage entirely free and open by taking away the Legs, applying a fine-

* *See Microſcope made eaſy*, Plate III. pag. 16.



A new constructed Double Microscope, as made & sold by the Inventor JOHN CUFF *in Fleet street London.*

Published according to Act of Parliament September 20th 1744.

fine-threaded Screw to regulate and adjuſt its Motions, and adding a concave Speculum for Objects that are opake.

The foregoing Examinations having been all made by an Inſtrument thus improved, I ſhall give a Plate and Deſcription of it, (as an Addition to my former Book on the Microſcope) by the Name of Mr. *Cuff's new-conſtructed Double Microſcope.*

All Parts of this Inſtrument are Braſs.—The Body A, being firmly ſupported in a broad circular Collar at the End of the Arm *a a*, which projects from the Top of the Pillar C, may be taken out or put in at Pleaſure.

A ſquare Box *b b*, ſcrewed down to the wooden Pedeſtal I I ſupports the whole Machine, by the Aſſiſtance of the long flat-ſquare Pillar B, which is fixt within the ſaid Box.

The moveable Pillar C, which is ſhorter than the Pillar B tho' of the ſame Shape, by ſliding up or down againſt the broad flat Side of the ſaid Pillar; raiſes or lowers the Body of the Microſcope as occaſion may require.—Both Pillars ſtand in the Box *b b*.

The ſquare Collar D holds the two Pillars B and C together, and ſlides up or down upon them, carrying with it the Body of the Microſcope.——The Screw-Button 3 is intended to fix the Pillar C, when the upper Edge of the Collar D being ſet at the ſame

Number as that of the Magnifier employed, its focal Diſtance is brought nearly right.

When the Pillar C is faſtened, the Microſcope (by the fine-threaded adjuſting Screw E) may be moved ſo gently up or down, without Jerks or Slips, that the true Focus may be found with great Readineſs and Exactneſs.

The horizontal Plate or Stage F, having in the Middle thereof a circular Hole 4, directly over which the Body of the Microſcope is ſuſpended, is exceedingly convenient to place Objects on for Obſervation, being freed intirely from the Legs which incumber other Double Microſcopes.

The concave Looking Glaſs G, turning on two ſmall Screws in the Arch *d* (at the Bottom of which a Pin goes down into the Hole *e* in the Pedeſtal) reflects the Light of a Candle or the Sky directly upwards on the Object, by moving the Looking Glaſs horizontally or vertically.

A double convex Lens H, turns on two Screws, for tranſmitting Light to aſſiſt in illuminating opake Objects, when the long round Wire *f* is placed in the Spring-Tube *g*, at the Corner of the Stage F.

I — is a hollow Cylinder whoſe Sides are open, and at whoſe End a concave Silver Speculum *h*, having a round Hole in the Midſt thereof, is ſcrewed. This Cylinder ſlips over the Snout *i* of the Microſcope, and when

when ſet to the Figure there marked, and correſpondent to the Number of the Magnifier made uſe of, the Silver Speculum reflects Light on the opake Object to be examined; which Object muſt either be held in the Spring-Tongs at one End of the Wire O, placed in the Slit *m* on the Stage F; or be put on the Ivory Block P, ſtuck on the pointed End of the ſaid Wire. The third or fourth Magnifiers are fitteſt to be uſed with the Silver Speculum.

K. L. M. N. Q Q. R. S. T. V. W. X. Y. Z. are different Parts of the Apparatus which I think needleſs to deſcribe, as all who are acquainted with *Microſcopes* will know them at firſt Sight, and others may inform themſelves either in my former Treatiſe on theſe Subjects, or in the Book which Mr. *Cuff* gives to thoſe who buy this Microſcope of him.

In the Year 1747 a Micrometer for this Inſtrument was alſo contrived by Mr. *Cuff*, being a Lattice of fine Wires, placed (when made uſe of) in the Focus of the Eye-Glaſs, by unſcrewing the Body of the Inſtrument. As the Readineſs wherewith the real Size of Objects may be calculated by this Micrometer muſt render it valuable to the Curious, there needs no Apology for laying ſome Account of it before them, drawn up and given to me by my much honoured Friend *Martin Folkes*, Eſq; Preſident of the *Royal Society*,

Society, and firſt Preſident, (under the Royal Charter, of the *Society of Antiquaries of London* †.

Remarks on a Micrometer *to be applied to Double* compound Microſcopes. By MARTIN FOLKES, Eſq; P. R. S.

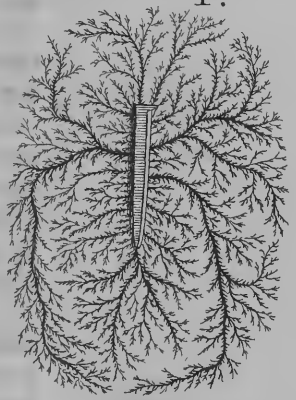
THIS Micrometer only conſiſts of a Lattiee of fine Silver Wire diſtant from each other one fiftieth Part of an Inch, interſecting at right Angles, and ſo placed in the Focus of the Eye Glaſs, as to divide the whole viſible Area of the Microſcope into Squares, whoſe Sides are each the $\frac{1}{50}$th of an Inch.

Now as the Image of any Object to be examined is formed in this Place, it is plain that by this Lattice Work ſuch Image may readily be meaſured, either by comparing its Length or Breadth with the Diſtance of the

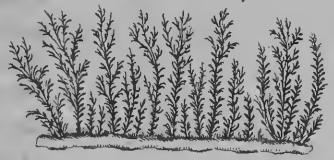
† This Gentleman, whoſe amiable Character for Ability in Science and Goodneſs of Heart is known and reſpected by all the World, being unhappily diſabled by a paralytic Diſorder from attending the Meetings of the *Royal Society*, where for eleven Years he had preſided with great Honour, thought proper on the laſt annual Day of Election, viz. *November* 30th 1752, to decline being again elected Preſident. Wherefore the Gentlemen of the ſaid Society, after returning their moſt grateful Acknowledgments to Mr. *Folkes* for his many and uſeful Services, elected unanimouſly the Right Honourable the *Earl* of *Macclesfield* to be their PRESIDENT in his Stead.

Pl. XVII. *p. 440.*

I.

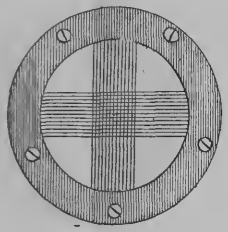


II.

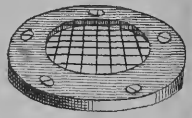


III.

IV.

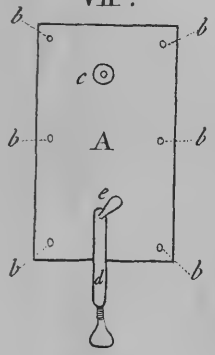


V.

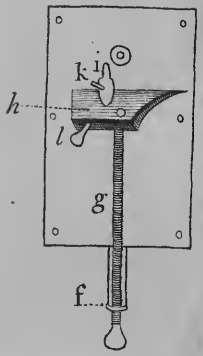


VI.

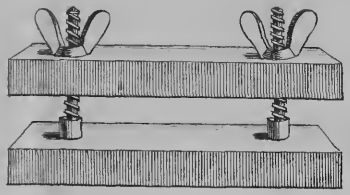
VII.



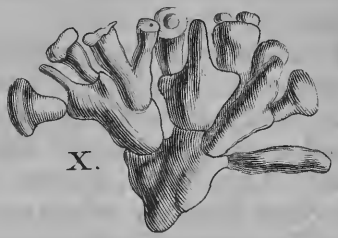
VIII.



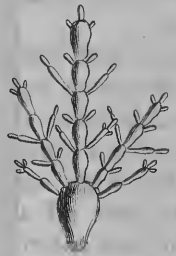
IX.



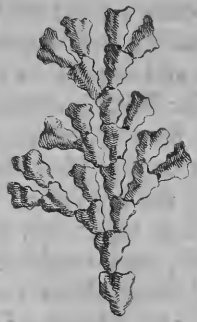
X.



XI.



XII.



D. E. B. delin.

J. Mynde sculp.

the Wires: or by comparing its whole viſible Superficies with one or more of the little Squares formed by the Interſection of the ſame Wires.

And the true Size of the magnified Image being thus known, the true Magnitude of the Object itſelf will be known alſo, if the magnifying Power of the Object Glaſs is but given: and this will eaſily be found in the following practical Manner.

Let a minute Object of a known Size, be carefully viewed in the Microſcope: as for example; Part of a fine diagonal Scale divided into the Milleſimals of an Inch; and let it be examined how many of thoſe Milleſimals anſwer to the Diſtance of two of the Wires abovementioned, remembering to eſtimate that Diſtance from the Outſide of one of the Wires to the Inſide of the other. For as 20 are to that Number of Milleſimals juſt found, ſo is the Length or Breadth of any Image meaſured by the Micrometer to the Length or Breadth of the Object itſelf: or as 400 are to the Square of the ſame Number of Milleſimals, ſo is the magnified Superficies of any Image, to the true ſimilar Superficies of the Object.

And again, as that Number of Milleſimals of an Inch juſt found is to 20, ſo is Unity to a Number expreſſing how many times the Length or Breadth of any Image eſtimated by the Micrometer, is greater than the true

Length or Breadth of the Object itſelf: and this laſt Number I call the magnifying Power of the Object Glaſs.

This Trial is to be made with Care once for all, for every different Object Glaſs to be uſed with the Micrometer: and their different reſulting magnifying Powers, once regiſtered in a Table, will be ready upon all Occaſions. For thus the Length or Breadth of any Image eſtimated by the Micrometer, will when di ided by the magnifying Power of the Object Glaſs, expreſs the true Length or Breadth of the Object itſelf: or the Superficies of any Image eſtimated by the Micrometer, in ſquare Milleſimals of an Inch, will in like Manner expreſs the true ſimilar Superficies of the Object itſelf; if it is divided by the Square of the magnifying Power of the Object Glaſs uſed. And for this Purpoſe it may be of uſe to ſet down in another Column of the Table, the reſpective Squares of the Numbers expreſſing the magnifying Powers of the ſeveral different Object Glaſſes.

As ſome Difficulty may be found, in applying the diagonal Scale abovementioned to the larger Magnifiers: chiefly thro' want of Light when the Object is to be brought very near to the Glaſs; that Defect may be ſupplyed by the uſe of ſome minute natural Object, whoſe true Size has already been carefully determined by one of the leſſer Magnifiers,

fiers, and whoſe Image is again viewed with one of the greater: for as the Number of Milleſimals of an Inch contained in its true Length or Breadth, are to thoſe now found in the Length or Breadth of its Image, ſo will Unity be to the magnifying Power of the Object Glaſs now made uſe of, *&c.*

I ſhould now farther take Notice, that the Numbers here called the magnifying Powers of the ſeveral Object Glaſſes, do not expreſs the whole magnifying Power of the Microſcope. For the Image formed in the Focus of the Eye Glaſs is again magnified to the Eye, by the Operation of the Eye Glaſs itſelf. And the Focus of this Eye Glaſs being, in the Double compound Microſcope made by Mr. *Cuff*, and which he calls (tho' ſomewhat improperly) his new double *reflecting* Microſcope, at the Diſtance of one Inch and a quarter nearly; the Eye, placed on the other Side, views the Image of any Object formed in that Focus under an Angle about ſeven times as great as that under which it would ſee it with Diſtinctneſs if naked, and at the Diſtance of ſomewhat leſs than nine Inches. We may therefore then conſider all Images viewed with this Microſcope as magnifyed ſeven times in Length or Breadth, or 49 times in Superficies by the Intervention of the Eye Glaſs: and we may conſequently expreſs the whole magnifying Powers of the Microſcope, if we reſpectively multiply the Numbers

Numbers already placed in two Columns of the Table, by 7 and 49.

I would juſt obſerve, that ſome Double Microſcopes have a Drawer between the Glaſſes, and by means of which they magnify differently with the ſame Glaſs: in theſe Microſcopes therefore one Poſition of the Drawer ſhould be pitch'd upon as the moſt convenient, and the ſame ſhould conſtantly be uſed whenever any Magnitude is to be determined by the Micrometer applyed to the ſame.

The Lattice abovementioned, whoſe Wires are only diſtant a fiftieth of an Inch, may upon ſome Occaſions be found inconvenient in viewing of Objects. But it may very eaſily be taken out and put in occaſionally, or have its Place ſupplyed by another whoſe Wires may be the 20th, or the 10th of an Inch aſunder; and this laſt eſpecially will give no hindrance to common Obſervations, and will beſides be very uſeful to ſuch as would draw with ſome Exactneſs any of the Objects they examine with their Microſcope.

I am told that Silver Wire may be had to make theſe Lattices of, whoſe Diameter is rather leſs than the ſeven hundredth Part of an Inch.

The mention Mr. *Folkes* makes of a Lattice whoſe Diviſions are $\frac{1}{10}$ of an Inch, was owing to his having experienced the Utility of ſuch an one in my Microſcope, made by myſelf of human Hairs, and faſtened exactly in

in the Focus of the Eye Glaſs, whoſe Diſtance being $1\frac{1}{4}$ Inch, or $\frac{5}{35}$ths of nine Inches, (the Standard of Sight he computes by *,) the Diameter of an Object ſeen through that Glaſs is magnified 7 times, and the Side of each Square whoſe real Length is $\frac{1}{10}$, appears (magnified through the ſaid Glaſs) to be $\frac{7}{10}$ths of an Inch.

Employing different Object Glaſſes or Magnifiers in viewing Objects, makes no Difference in the Lattice or Micrometer, whoſe Squares are magnified by the Eye Glaſs only, and always appear of the ſame Diameter, that is, $\frac{7}{10}$ths of an Inch. But the Object being more or leſs magnified according to the Power of the Object Glaſs, the Image thereof thrown upon the Lattice extends over more or fewer of its Squares: whence the magnifying Power of all the Glaſſes belonging to my Microſcope, and the real Size of Objects examined by them, are ſhewn in the following Table.

A Table

* The uſual Standard of Sight is 8 Inches, but as Mr. *Folkes* has thought proper to make it almoſt 9 Inches, all theſe Calculations are conformable thereto.

A Table of the *magnifying Powers* of the Glaſſes belonging to my own *Double compound Microſcope*, together with the Meaſure of a ſingle Square of the *Micrometer* compoſed of tenths of an Inch, when any one of the Glaſſes is employed; according to the foregoing Method of Calculation.

When the Object Glaſs N° is made uſe of	An Object is magnified in Diameter	Magnified in Superficies	The Side of each Square in the Hair Micrometer meaſures the	The Area of each Square in the Hair Micrometer meaſures the
	Times.	Times.		
0*	320	122500	500th	250000th
1	189	35621	270	72900
2	161	25921	230	52900
3	84	7056	120	14400
4	49	2401	70	4900
5	28	754	40	1600
6	17½	306¼	25	625
			Part of a magnified Inch in Length.	Part of a magnified ſquare Inch.

The Magnifiers are diſtinguiſhed in the firſt Column by the N° 1, 2, 3, &c.
The ſecond Column ſhews how many times each Glaſs magnifies the Diameter of any Object.
The third Column ſhews how many times each Glaſs magnifies the Superficies of any Object.
The fourth Column determines the true Length of any Object, by ſhewing what Part of the Length of an Inch ſuch Object really is, when viewed by either of the Glaſſes, it appears the Length of one Square of the Micrometer.
The fifth Column determines the true Size of any Object, by ſhewing what Part of a Square Inch ſuch Object really is, when, viewed by either of the Glaſſes, it fills up the Area of one Square of the Micrometer.

* This Glaſs, whoſe magnifying Power is extraordinary, was made particularly for me.

For Example.——An Object, or Part of an Object, whose Diameter when viewed through the Magnifier N° 1. appears the exact Length of one Square of the Hair Micrometer, is really no more than the 270th Part of an Inch in Length.

And if, when viewed through the same Glass, it appears to fill up the whole Space of one of the said Squares, its real Area is no more than the 72900th Part of a Square Inch, *&c.*

In order to render this Instrument still more useful, Squares may be drawn on Paper (with very black Lines) correspondent to those of the Micrometer magnified by the Eye Glass, *viz.* $\frac{1}{10}$ths of an Inch diameter; by the Means whereof, (if placed under so thin a Paper as they can plainly be seen through,) an Object may be drawn exactly of the Size it appears when magnified by any Glass whatever. —— Nine Squares so drawn are shewn *Plate* XVII. *fig.* 6.

In the same Plate, *fig.* 4, shews a Micrometer whose Divisions are the Fiftieths, and *fig.* 5, another whose Divisions are the Tenths of an Inch: And this last may remain in the Body of the Microscope, without being any Hindrance, whatever Glass is used.

'Twere well if the Workmen ground their Glasses so exactly to a Standard, that the same Table might serve for the Micrometer to every Set of them; but as that is

not the Caſe, a particular Table muſt be made for every Set of Glaſſes.

Of Mr. LEEUWENHOEK's *Microſcopes.*

THough Mr. *Leeuwenhoek*'s Microſcopes are much talked of, very few People are acquainted with their Structure and Apparatus, no Figure of them that I remember having ever been made publick: 'tis therefore hoped the Curious will be pleaſed to ſee a Drawing of them, taken with great Exactneſs from thoſe in the Repoſitory of the *Royal Society*, which are all alike in Form, and differ very little in Size from this Drawing, or from one another *.

The two Sides of one of theſe Microſcopes are ſhewn *Plate* XVII. *fig.* 7 and 8. The Eye muſt be applyed to the Side *fig.* 7.— The flat Part A is compoſed of two thin Silver Plates faſtened together by little Rivets *b b b b b b*. Between theſe Plates a very ſmall double-convex Glaſs is let into a Socket, and

* An accurate Deſcription of the 26 Microſcopes, and Objects belonging them; contained in a ſmall Cabinet which Mr. *Leeuwenhoek* at his Deceaſe bequeathed to the *Royal Society*, was preſented many Years ago to that Society by *Martin Folkes*, Eſq; and may be ſeen N° 380 of the *Philoſophical Tranſactions*. And a farther Account, ſetting forth the *magnifying Powers*, and other Particulars concerning the ſame Microſcopes, (which were three Months under my Examination for that Purpoſe) was preſented by me to the *Royal Society* in the Year 1740, and publiſhed *Phil. Tranſ.* N° 458. But neither of theſe Accounts has any Drawing of the Microſcopes.

and a Hole drilled in each Plate for the Eye to look through at *c*. A Limb of Silver *d* is faſtened to the Plates on this Side by a Screw *e* which goes through them both. Another Part of this Limb, joined to it at right Angles, paſſes under the Plates, and comes out on the other Side; (*vid. fig.* 8) at *f*: through this runs, directly upwards, a long fine-threaded Screw *g*, which turns in and raiſes or lowers the Stage *h*, whereon a coarſe rugged Pin *i* for the Object to be faſtened to, is turned about by a little Handle *k*; and this Stage with the Pin upon it is removed farther from the magnifying Lens, or admitted nearer to it, by a little Screw *l*, that paſſing through the Stage horizontally, and bearing againſt the Back of the Inſtrument, thruſts it farther off when there is occaſion. The End of the long Screw *g* comes out thro' the Stage at *m*, where it turns round, but acts not there as a Screw, having no Threads that reach ſo high.

Theſe Microſcopes are plain and ſimple in their Contrivance. All the Parts are Silver, faſhioned by Mr. *Leeuwenhoek*'s own Hand, and the Glaſſes, which are excellent, were all ground and ſet by himſelf. He glewed one or at moſt two Objects on the Point of the Pin belonging to each Microſcope, and carefully preſerved them there; ſo that each Inſtrument being devoted to one or two Ob-

jects only, could be applyed to nothing elſe. This Method induced him to make a Microſcope with a Glaſs adapted to almoſt every Object, 'till he had got ſome hundreds of them, as he ſays himſelf, in the 2d Vol. of his Works, *pag.* 290, *Mihi quidem ſunt centum centumque Microſcopia*, &c. All this Trouble and Expence is now ſaved, by a Set of Glaſſes to be ſhifted with great Eaſe, as the Subject to be examined may require.

The magnifying Powers of theſe Glaſſes come ſhort of ſome now made, but are fully ſufficient for moſt Purpoſes. Of the 26 Microſcopes I examined, one magnifies the Diameter of an Object 160, one 133, one 114, three 100, three 89, eight 80, two 72, three 66, two 57, one 53, and one 40 times.

Directions for obtaining an exact Repreſentation or Picture of any COIN *or* MEDAL.

HAVING taken a perfect and ſharp Impreſſion of the Coin or Medal in the fineſt Sealing Wax, cut the Wax away round the Edges of the Impreſſion, with the Point of a Penknife, or a Pair of ſharp Sciſſars.

The Rolling-Preſs Printers have an Ink for printing off Copper Plates, very different from what other Printers employ in printing Books: work ſome of this with an Hair-

Pencil into all the Lettering and hollow Places of the Wax Impreſſion, which are the riſing or projecting Parts of the Medal. This done, paſs your bare Finger, or a Cloth ſtrained upon it, gently but nimbly over the Surface, 'till you perceive the Ink perfectly cleared away, unleſs where the Letters are, and in the ſinking Parts; and after this, rubbing your Finger on a Piece of ſoft Whiting, paſs it lightly over the Surface 'till you are ſure it is dry and clean.

Have ready, ſoaked in Water, but the Water ſqueezed a little out of them, ſome Pieces of Writing Paper ſomewhat larger than the Medal. Place one of theſe on the Wax Impreſſion; and on the Back of the Paper lay three or four Pieces of thick Flannel about the Size thereof.

I ſhould premiſe, that you muſt have a Couple of flat ſmooth Iron Plates, about two Inches Square, and of a Thickneſs not to bend. The Wax Impreſſion muſt be placed, with its Face upwards, on the Middle of one of theſe Plates, before you ſpread the Paper and Flannels on it; and the other Plate muſt immediately be laid over them. Then, holding them all tight together, put them carefully and evenly into a little Preſs, made of two Iron Planks about five Inches and a half long, one Inch and half wide, and half an Inch in Thickneſs: having a Couple of male

Screws that run through them, with a turning female Screw on each to force the Planks together. And these female Screws must have strong well-tempered Shoulders, whereby to work them. A Figure of this Press is shewn *Plate* XVII. *fig.* 9.

Things being thus adjusted, holding the Press in your Left-Hand, strike with a little Hammer, first on the Shoulders of one Screw, and then on the Shoulders of the other, to bring the Planks together parallel and render the Pressure every-where alike; unless you find it requisite to give more Force to one Side than the other, which these two Screws will put in your own Power.

The Press opens again, by a Stroke or two of the Hammer, the contrary Way, on the Shoulders of the Screws: and then you will find a true and fair Picture neatly printed off; which (if any Deficiencies appear therein) may be easily repaired, when dry, with a Pen and Ink, or, what is better, a Pencil and Indian Ink.

This Method is very easy and ready for taking the Picture of a Medal either in Black or Red; proper Ink of both which Colours may be had of the *Copper-Plate Printers*: but your Wax Impression must be different in Colour to that of the Ink you use, otherwise you cannot see when the Ink is well cleared away; and as the whole Success depends

pends on the Goodneſs of the Wax Impreſſion or Mould, the following Rules, taught by Experience, are recommended to be obſerved.

1. Let the Wax be fine, or it wants a proper Hardneſs, and the Impreſſion will not be ſharp.
2. Spread it wider than the Medal, and of a Thickneſs in proportion to the *Relievo* of it.
3. Clap on the Medal when the Wax has a moderate Degree of Heat: for, if it be too hot, the Medal is apt to ſtick: and, if too cold, no good Impreſſion can be taken. The right Time ſeems to be, juſt after the Wax ceaſes to work up with little Bubbles in it.
4. Make not the Impreſſion on a Table or any hard Body, without ſeveral Folds of Paper, or, what is better, a Woollen-Cloth, or ſome ſoft Leather underneath; for ſoft Things give Way to the Preſſure and Form of the Medal, which hard Bodies will not do.
5. Squeeze the Medal down equally hard on every Side, and continue the Preſſure 'till the Wax is near cold: for if the Medal be taken off while the Wax remains hot, the riſing Parts being ſtill ſoft, will ſink down, and the Impreſſion be much leſs ſharp.

6. White Paſteboard, Card-Paper, or ſome other thick Paper, is beſt to take Wax Impreſſions on.

In Places where *Copper-Plate Printer's Ink* cannot be had, Water-Colours may be made uſe of. Lake and Vermillion mixt make the moſt proper Red, Indian Ink the beſt Black. Directions for other Colours may be ſeen, *Phil. Tranſ.* N° 472, p. 82; in an Account of this Invention laid by me before the *Royal Society* Anno 1744, from whence this is partly taken.

There are indeed many other ingenious Contrivances for taking off Medals, in Sulphur, Plaiſter of Paris, Paper, *&c.* But ſince a Mould muſt be formed for each of theſe, either of Clay, Horn, Plaiſter of Paris, or ſome other Materials, which requires a great deal of Trouble and Time to form, this Method I believe will be judged abundantly more convenient, eſpecially as ſome of thoſe ways do really a great deal of Injury to Medals, by impairing the Sharpneſs of their moſt delicate and expreſſive Strokes.

For Wax is always ready, and hurts not the fineſt Medal: and however brittle it may be thought, the Moulds made thereof reſiſt the Force of downright Preſſure, almoſt as effectually as if they were made of Steel; and might ſerve to take off a thouſand Impreſſions, were they not apt to crack, and the Marks of thoſe Cracks to render what

what are taken from them afterwards not quite ſo elegant. But each Mould will uſually afford three or four good Impreſſions, either coloured or plain; and if the Ink be got off clean, the ſame Wax may be melted and employed ſeveral Times.

It is evident, that Impreſſions taken thus, muſt be exactly what the Medals are from whence we take them, and that any Perſon who can procure the Wax Impreſſions of Medals, may, by a little Pains, be furniſhed with a noble Collection of the genuine Prints of Medals; which may be placed in Books, in orderly Series, and moved from one Leaf to another at Pleaſure; if a little Margin be left about them, and only the Edges be paſted down. I flatter myſelf therefore, that the Uſefulneſs of this Contrivance will not be ſlighted, on account of its being ſo plain and obvious, that every Gentleman will wonder he did not hit on it himſelf; ſince Diſcoveries that are moſt eaſy, and conſequently may be practiſed by every body, however ſimple and void of Invention they may appear, are really in themſelves moſt valuable. I need only inſtance the Art of Printing, (from which this in ſome ſort is borrowed) the moſt happy Diſcovery that perhaps was ever made by Man; yet ſeemingly ſo eaſy, and what the Ancients came ſo near to in their Seals, that

it

it is extremely ſurpriſing they did not find it out.

In this Manner I have taken off many thouſands of Coins and Medals for myſelf and Friends: and as any Gentleman may divert himſelf by doing it, I hope this Account of it may prove acceptable.

As the laſt *Plate* was not finiſhed till the whole Book was nearly printed off, whereby ſome Figures in it are not deſcribed in their proper Places: It may be needful to inform the Reader, that N° I, II, III, are different *Branchings of Copper*, produced by the ſeveral Mixtures mentioned CHAP. LIII. PART I. — That N° X, XI, are two Species of *Corallina marina*, and N° XII a Species of *Fucus marinus*, all magnified by the Microſcope.

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